JOURNAL
OF
AMERICAN CONCRETE INSTITUTE

VOL. II APRIL—SEPTEMBER, 1914 Nos. 3, 4, 5.

CONTENTS

PART I—Institute Affairs PAGE

Officers ... 2
Editorial ... 3
List of Standards ... 4

PART II—Papers, Discussions and Reports
(Concluding Volume X of the Proceedings)

Contents and Other Prefatory Matter of Volume X ... 1-8
Combination of Reinforcement and Forms in Concrete Construction—T. W. Murray ... 228
Discussion ... 233
Progress and Development of Concrete Work on the Delaware, Lackawanna and Western Railroad—A. B. Cohen ... 239
Progress Report on Tests of Concrete in Sea Water at the Navy Yard, Charlestown, Mass.—Leonard C. Wason ... 265
Steel Forms for Concrete Construction—C. D. McArthur ... 278
Discussion ... 293
Full Size Tests and Their Value in Concrete Construction—Burtis S. Brown ... 299
Discussion ... 306
Report of Committee on Treatment of Concrete Surfaces ... 313
Standard Specifications for Portland Cement Stucco ... 315
Proposed Standard Specifications for Portland Cement Stucco on Wood Lath ... 324
Discussion ... 330
The Artistic Treatment of Concrete Structures—Oliver Randolph Parry 339
Discussion ... 342
Report of Committee on Building Blocks and Cement Products ... 344
Recommended Practice for Plain Concrete Pipe and Drain Tile ... 345
Recommended Practice for Concrete Architectural Stone, Building Block and Brick ... 352
Recommended Practice for Concrete Fence Posts ... 358
Standard Building Regulations for the Use of Concrete Architectural Stone, Building Block and Brick ... 362
Concrete Posts to Fill the Gap—A. M. Smith ... 365
Discussion ... 513
The Problems of the Contractor—Leonard C. Wason ... 369
Discussion on Report of Committee on Specifications and Methods of Tests for Concrete Materials ... 525
Discussion on Some Comparative Corrosion Tests of Plastered Metal Lath ... 533
Discussion on Data on Lime Putty and Cream of Lime ... 536
Discussion on The Layout of Concrete Products Plants ... 538
Indices and Other Concluding Matter of Volume X ... 541

PUBLISHED BY THE INSTITUTE
Copyright, 1917 by the American Concrete Institute

this page doesn't belong in Vol 10.

OFFICERS

President

WILLIAM K. HATT
(Term expires 1918)

Vice-Presidents

HENRY C. TURNER
(Term expires 1918)

SANFORD E. THOMPSON
(Term expires 1919)

Directors

First District
CHARLES R. GOW

Second District
EDWARD D. BOYER

Third District
ERNEST ASHTON

Fourth District
WILLIAM P. ANDERSON

Sixth District
JOHN G. TREANOR
(Term expires 1918)

Fifth District
WILLIAM M. KINNEY
(Term expires 1919)

Secretary

HAROLD D. HYNDS
(Term expires 1918)

Treasurer

ROBERT W. LESLEY
(Term expires 1918)

Past-Presidents

RICHARD L. HUMPHREY

LEONARD C. WASON

Executive Committee

William K. Hatt, *Chairman*

Henry C. Turner
Edward D. Boyer
Robert W. Lesley
Harold D. Hynds

Publications

Frank C. Wight, *Chairman*

Edward D. Boyer
Cloyd M. Chapman
William K. Hatt
Richard L. Humphrey

Finance

William K. Hatt, *Chairman*

Henry C. Turner
Robert W. Lesley

PURPOSE OF THE INSTITUTE

It is the purpose of the Institute, by means of conventions and publications, to increase and disseminate knowledge in regard to the use of cement, concrete and allied products; to conduct research into their properties and uses; and to formulate recommended practice and standard specifications. Its objects are purely educational.

JOURNAL
OF
AMERICAN CONCRETE INSTITUTE

FOUNDED 1905, AND INCORPORATED 1906, AS
NATIONAL ASSOCIATION OF CEMENT USERS
CHARTER AMENDED JULY 2, 1913

The Institute is not responsible, as a body, for statements and opinions advanced in its publications.

VOL. II APRIL—SEPTEMBER, 1914 NOS. 3, 4, 5.

COMPLETION OF VOLUME X OF THE PROCEEDINGS.

It was announced in the February, 1914, Journal of the Institute that the Proceedings of the Tenth Annual Convention would be published as Part II in the ensuing seven numbers, the pages of which would be numbered serially, and on completion there would be furnished to the members, the Table of Contents and the usual prefatory matter and information heretofore found in the Annual Volume of the Proceedings. The latter, together with the second part of the seven numbers of the Journal, could then be bound together to form a complete volume of the Proceedings. Numbers 1, 2, 6 and 7, have already been published; Numbers 3, 4 and 5 are published herewith. In Part II of this Journal will be found all the remaining matter which may be combined with Part II of Volumes 1, 2, 6 and 7, and this completes Volume X.

STANDARDS ADOPTED BY THE INSTITUTE.

1. Standard Specifications and Tests for Portland Cement, 20 pp.
2. Standard Specifications for Portland Cement Sidewalks, 6 pp.
3. Standard Specifications for Cement Hollow Building Blocks, 9 pp.
4. Standard Building Regulations for the Use of Reinforced Concrete, 13 pp.
5. Standard Specifications for One-Course Concrete Highway, 8 pp.
6. Standard Specifications for Concrete Curb and Concrete Curb and Gutter, 7 pp.
7. Standard Recommended Practice. The Report of Committee on Reinforced Concrete, 21 pp.
8. Standard Specifications for Scrubbed Concrete Surface, 3 pp.
9. Standard Recommended Practice for Plain Concrete Pipe and Drain Tile, 7 pp.
10. Standard Recommended Practice for Concrete Architectural Stone, Building Block and Brick, 6 pp.
11. Standard Specifications for Concrete Architectural Stone, Building Block and Brick, 3 pp.
12. Standard Building Regulations for the Use of Concrete Architectural Stone, Building Block and Brick, 4 pp.
13. Standard Specifications for Plain Concrete Floors, 6 pp.
14. Standard Specifications for Reinforced Concrete Floors, 5 pp.
15. Standard Specifications for Portland Cement Stucco, 9 pp.
16. Standard Methods for the Measurement of Concrete Work, 8 pp.
17. Standard Specifications for One-Course Concrete Street Pavement, 8 pp.
18. Standard Specifications for Two-Course Concrete Street Pavement, 9 pp.
19. Standard Specifications for One-Course Alley Pavement, 8 pp.
20. Standard Specifications for Concrete Pavement Between Street Car Tracks, 7 pp.
21. Standard Specifications for Reinforced Concrete Fence Posts, 3 pp.
22. Standard Specifications for Drain Tile, 17 pp.

The above Standards can be obtained at the price of 25 cents each or in lots of ten or more at 20 cents each. Special price to Members 15 cents each or 10 cents each in lots of ten.

PART II

PROCEEDINGS OF TENTH ANNUAL CONVENTION

Papers, Discussions and Reports

(Concluded).

AMERICAN CONCRETE INSTITUTE

PROCEEDINGS

OF THE

TENTH ANNUAL CONVENTION

Held at Chicago, Ill.,

February, 16, 17, 18, 19, 20, 1914

VOLUME X

EDITED BY RICHARD L. HUMPHREY

PUBLISHED BY THE INSTITUTE

1917

COPYRIGHT 1917 BY AMERICAN CONCRETE INSTITUTE

The Institute is not responsible, as a body, for the statements and opinions advanced in its publications.

CONTENTS.

	PAGE
Officers	5
Technical Committees	6
Past Officers	8
Summary of the Proceedings of the Tenth Annual Convention	9
Annual Report of the Board of Direction	22
Abstract of Minutes of Meetings of the Board of Direction	27
Register of Attendance—Tenth Convention	31
Annual Address by the President, The Use of Concrete in Hydraulic Works—Richard L. Humphrey	33
Specifications for Drain Tile—A. Marston	54
Discussion	134
Results of Tests on Plain and Reinforced Concrete Tile—George P. Dieckmann	60
Discussion	136
Investigation of the Durability of Cement Drain Tile in Alkali Soils—R. J. Wig and G. M. Williams	65
Some Essential Requirements in Concrete Pavements—R. C. Stubbs	108
Discussion	124
Reinforced Concrete Pavements and Roadways—B. S. Pease	112
Discussion	119
Topical Discussion on the Manufacture of Cement Products	126
Methods and Cost of Concrete Road Construction in Milwaukee County—H. J. Kuelling	141
Discussion	146
The Expansion and Contraction of Concrete Roads—R. J. Wig and W. S. Gefvert	155
Discussion	162
Report of Committee on Concrete Roads and Street Pavements	167
Standard Specifications for One-Course Concrete Highway	168
Standard Specifications for One-Course Concrete Street Pavement	178
Standard Specifications for Two-Course Concrete Street Pavement	188
Discussion	199
Report of Committee on Reinforced Concrete Highway Bridges and Culverts	219
Combination of Reinforcement and Forms in Concrete Construction—T. W. Murray	228
Discussion	233
Progress and Development of Concrete Work on the Delaware, Lackawanna and Western Railroad—A. B. Cohen	239
Progress Report on Tests of Concrete in Sea Water at the Navy Yard, Charlestown, Mass.—Leonard C. Wason	265
Steel Forms for Concrete Construction—C. D. McArthur	278
Discussion	293

PAGE

Full Size Tests and Their Value in Concrete Construction—Burtis S. Brown 299
Discussion 306
Report of Committee on Treatment of Concrete Surfaces 313
Standard Specifications for Portland Cement Stucco 315
Proposed Standard Specifications for Portland Cement Stucco on Wood Lath 324
Discussion 330
The Artistic Treatment of Concrete Structures—Oliver Randolph Parry 339
Discussion 342
Report of Committee on Building Blocks and Cement Products 344
Recommended Practice for Plain Concrete Pipe and Drain Tile 345
Recommended Practice for Concrete Architectural Stone, Building Block and Brick 352
Recommended Practice for Concrete Fence Posts 358
Standard Building Regulations for the Use of Concrete Architectural Stone, Building Block and Brick 362
Concrete Posts to Fill the Gap—A. M. Smith 365
Discussion 513
The Problems of the Contractor—Leonard C. Wason 369
Test of a Flat Slab Reinforced Concrete Floor at Shredded Wheat Factory, Niagara Falls, N. Y.—W. A. Slater 385
Report of Committee on Specifications and Methods of Tests for Concrete Materials 422
Discussion 525
Some Comparative Corrosion Tests of Plastered Metal Lath—J. C. Pearson 445
Discussion 533
Data on Lime Putty and Cream of Lime—Cloyd M. Chapman 459
Discussion 536
The Properties of Portland Cement Having a High Magnesia Content—P. H. Bates 470
The Layout of Concrete Products Plants—E. S. Hanson 485
Discussion 538
Modern Concrete Work Without Forms—James E. Payne 506
Charter 541
Change in Title of Organization 542
By-Laws 544
Subject Index 549
Author Index 556
List of Publications 562

PLATES.

I. Fig. 6.—Specimens Nos. 1 to 12, inclusive ..... (opposite) 270
II. Fig. 7.—Specimens Nos. 13 to 20 and Nos. 22 to 24, inclusive ..... (opposite) 270

OFFICERS

President

RICHARD L. HUMPHREY.
(Term expires 1915)

Vice-Presidents

ARTHUR N. TALBOT
(Term expires 1915)

LEONARD C. WASON
(Term expires 1916)

Directors

FIFTH DISTRICT
BENJAMIN F. AFFLECK*

SECOND DISTRICT
EDWARD D. BOYER

FOURTH DISTRICT
WILLIAM P. ANDERSON

SIXTH DISTRICT
JOHN B. LEONARD

FIRST DISTRICT
WILLIAM L. CHURCH*
(Term expires 1915)

THIRD DISTRICT
ROBERT W. LESLEY
(Term expires 1916)

Secretary

EDWARD E. KRAUSS
(Term expires 1915)

Treasurer

ROBERT A. CUMMINGS
(Term expires 1915)

Executive Committee

Richard L. Humphrey, *Chairman*
Leonard C. Wason
Edward D. Boyer
Robert A. Cummings
Edward E. Krauss

Publications

Arthur N. Talbot, *Chairman*
Robert A. Cummings
Leonard C. Wason
Edward E. Krauss
Robert W. Lesley
Richard L. Humphrey

Finance

Leonard C. Wason, *Chairman*
Edward D. Boyer
Robert A. Cummings

PURPOSE OF THE INSTITUTE

It is the purpose of the Institute, by means of conventions and publications, to increase and disseminate knowledge in regard to the use of cement, concrete and allied products; to conduct research into their properties and uses; and to formulate recommended practice and standard specifications. Its objects are purely educational.

* Messrs. William K. Hatt and Henry C. Turner were elected by the Board of Direction October 8, 1914, to fill the vacancies, caused by resignation, of Messrs. Benjamin F. Affleck and William L. Church respectively.

TECHNICAL COMMITTEES.

BUILDING BLOCKS AND CEMENT PRODUCTS.

C. K. Arp, *Chairman.*

E. S. HANSON,
J. K. HARRIDGE,
ROBERT F. HAVLIK,
H. H. MUSSELMAN.

EDISON FIRE.

Cass Gilbert, *Chairman.*

WALTER COOK,
WILLIAM H. HAM,
RUDOLPH P. MILLER,
E. J. MOORE,
CHARLES L. NORTON,
J. KNOX TAYLOR,
RICHARD L. HUMPHREY.

FIREPROOFING.

John S. Sewell, *Chairman.*

EDWIN CLARK,
RUDOLPH P. MILLER,
WILLIAM C. ROBINSON,
IRA H. WOOLSON.

INSURANCE.

J. P. H. Perry, *Chairman.*

WILLIAM H. HAM,
ALBERT L. JOHNSON,
WILLIAM H. MERRILL
F. W. MOSES.

NOMENCLATURE.

Frank C. Wight, *Chairman.*

PETER GILLESPIE,
E. P. GOODRICH,
E. J. MEHREN,
F. E. TURNEAURE.

REINFORCED CONCRETE AND BUILDING LAWS.

Alfred E. Lindau, *Chairman.*

WILLIAM P. ANDERSON,
E. J. MOORE,
SANFORD E. THOMPSON,
ARTHUR N. TALBOT.

Technical Committees.

REINFORCED CONCRETE HIGHWAY BRIDGES AND CULVERTS.

Willis Whited, *Chairman.*

LEMUEL HOLMES,
ARTHUR N. JOHNSON,
ANDREW M. LOVIS,
HENRY H. QUIMBY.

ROADS AND PAVEMENTS.

C. W. Boynton, *Chairman.*

FRED CHARLES,
EDWARD N. HINES,
A. R. HIRST,
JOHN B. HITTELL,
ARTHUR N. JOHNSON,
THOMAS H. MAC DONALD,
JAMES R. MARKER,
H. G. SHIRLEY,
FRED C. SMITH,
PERCY H. WILSON.

SIDEWALKS AND FLOORS.

Lewis R. Ferguson, *Chairman.*

SPECIFICATIONS AND METHODS OF TESTS FOR CONCRETE MATERIALS.

Sanford E. Thompson, *Chairman.*

CLOYD M. CHAPMAN,
RUSSELL S. GREENMAN,
WILLIAM M. KINNEY,
ARTHUR N. TALBOT.

TREATMENT OF CONCRETE SURFACES.

Leonard C. Wason, *Chairman.*

CLOYD M. CHAPMAN,
L. R. FERGUSON,
H. B. MC MASTER,
J. C. PEARSON.

PAST OFFICERS.

President.	1905	John P. Given. (Presiding Officer First Convention.)
	1905–	Richard L. Humphrey.
First Vice-President.	1905	A. L. Goetzmann.
	1906–9	Merrill Watson.
	1909–12	Edward D. Boyer.
	1912–	Arthur N. Talbot.
Second Vice-President.	1905–6	John H. Fellows.
	1907–10	M. S. Daniels.
	1911–12	Arthur N. Talbot.
	1912–	Leonard C. Wason.
Third Vice-President.	1905	H. C. Quinn.
	1906–7	O. U. Miracle.
	1908	S. B. Newberry.
	1909–12	E. S. Larned.
Fourth Vice-Presidents.	1905–7	A. Monsted.
	1908–9	George C. Walters.
	1909–10	F. A. Norris.
	1911–12	Ira H. Woolson.
Treasurer.	1905	A. S. J. Gammon.
	1906–12	H. C. Turner.
	1912–	Robert A. Cummings.
Secretary.	1905–6	Charles C. Brown.
	1907	W. W. Curtis.
	1908–9	George C. Wright.
	1910	Edward E. Krauss (Acting)
	1911–	Edward E. Krauss.

NOTE.

Pages 9 to 226 may be found in the

JOURNAL OF AMERICAN CONCRETE INSTITUTE,

Volume II, Numbers 1 and 2.

to figure live load on the culvert, only assuming that it is distributed, *i. e.*, not figuring for concentrated and eccentric loading.

Par. 8. A 15-ton road roller is liable to be on any county bridge and it may have 11 tons on the rear axle.

Par. 13. Should be rewritten in the light of recent tests and the lateral distribution should be a function of the thickness of slab instead of a porportion of the length of span. The engineering papers—or perhaps the Am. Soc. C. E. Transactions—contained a few months ago a report of tests of distribution of a vertical load through sand. I have searched for it but do not find it. We might recommend 1 horizontal to 2 vertical as current practice.

Par. 15. What recommended method is referred to?

What does "each direction" mean? Longitudinal and transverse or only transverse both ways from the point. In the latter case omit "each direction" and say *four times* the thickness.

Par. 18. If we go into such specifications we ought to cover steam driving as well as drop driving. I think that the Engineering News formula for steam driving is quite too liberal.

Par. 25. Is there not some error in your formula for waterway? For a drainage area of 6,000 acres it gives from 1,350 to 9,000 sq. ft. area of culvert. Talbot's formula gives from 130 to 690 sq. ft. Myers' gives from 77 to 308 sq. ft. Our sewer formula for a district with almost no absorption because of roofs and pavements and where there must be no damming back for a moment gives 2,500 sq. ft. A recent bridge built by this City over Frankford Creek at tide water has 350 sq. ft. for each 6,000 acres of drainage area, and the Chestnut Street bridge over the Schuylkill River has about 50 sq. ft. for each 6,000 acres.

COMBINATION OF REINFORCEMENT AND FORMS IN CONCRETE CONSTRUCTION.

By T. W. Murray.*

Although concrete construction dates back to the earliest days of history, it has been in the last decade only that a real development has been made in reinforced concrete construction, particularly in building work. The heavy masses of concrete and unscientific design of the reinforcement used in the earlier methods of concrete construction seem crude today.

Methods of reinforcement developed rapidly. Today there are complete systems of reinforcement, that scientifically and economically provide for all the stresses due to direct bending, shear, compression, continuity, etc. These many improvements have resulted in lighter and stronger construction. There is no building or structural material that is given as thorough and scientific study in its design as reinforced concrete. The plastic and monolithic properties of the latter material present possibilities of great value to the skilful designer.

Forms have ever been the bugbear of concrete construction. This fact has always been recognized, but assumed increased importance with the development of scientific design and the growing scarcity of lumber. The earlier efforts of reinforced concrete engineers were directed toward simplifying and reducing the quantity and the cost of form work. In those days were developed systems of long span construction. the principal one among these being the reinforced hollow tile construction. This construction not only greatly reduces the cost of the forms, but also reduces the weight of the construction as compared with solid concrete. In later years this construction has been still further improved by the substitution of metal for terra-cotta tile, thus permitting much lighter construction and greater economy.

Other designers have been busy developing systems of standardized forms, both in metal and wood. There are a number of

* Manager. Hy-Rib Department, Trussed Concrete Steel Company, Detroit, Michigan.

such methods, but none of them has met with any marked success in building construction, owing to the practical impossibility of standardizing their design.

The most important advance which has been made in solving the problem of forms, was the introduction, about six years ago, of a combination of reinforcement and forms. This was in the form of deep ribs connected by a special expanded lath manufactured from steel plates. The mesh between the ribs holds the concrete from falling through when placed in a horizontal position. When placed in a vertical position this expanded lath

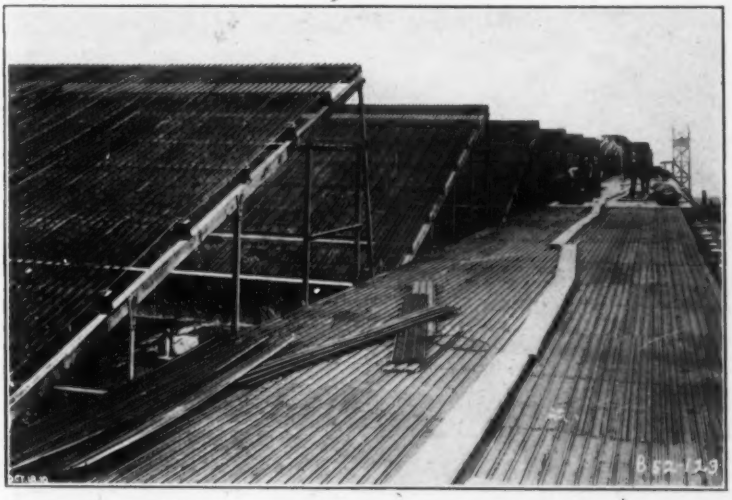


FIG. 1.—SAW TOOTH AND FLAT ROOF CONSTRUCTION.

forms an ideal surface for plastering. The ribs and the mesh combined act as a reinforcement for the concrete, thus eliminating the necessity for forms. The use of this expanded metal is simple. All that is necessary is to take the large sheets, lay them over the supports, pour on the concrete to the required thickness, and plaster the lower surface.

Opportunity for the use of a material of this nature is found in practically every field of building construction. In roofs, besides saving the expense of forms, it makes possible a very thin roof of light weight, which results in a marked saving in all the

supporting framework. In walls and sidings this material is attached to the supporting framework and plastered on both sides to the required thickness which totals usually about 2 in. This solid monolithic wall built entirely without forms has great strength and rigidity. Such a wall costs only about one-half as much as other masonry construction, and occupies about 2 in. of space, thus increasing the inside dimensions of rooms from 12 to 20 in. For partitions this material is attached to floors and ceilings, and plaster applied on both sides. Such a partition

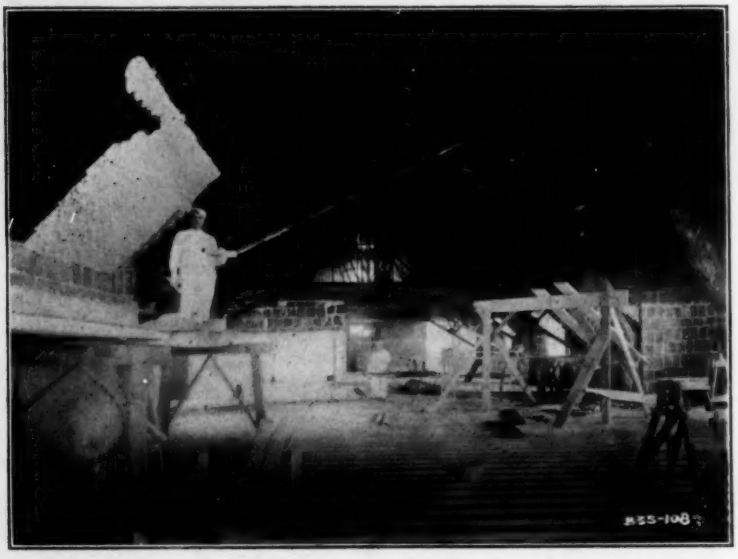


FIG. 2.—THE PLASTERING OF CEILINGS.

is about 2 in. thick, strong, permanent, fireproof and sound-proof. Its thinness adds considerably to the size of the rooms, increasing the revenue of the building. In ceilings, the material is merely attached to the lines of support, spaced from 3 to 6 ft. apart and the plaster applied to the under side, thus eliminating the expense of wiring lath to a great number of channels. This reinforcement also has similar advantages when used as furring.

Expanded metal is also furnished in the form of curved sheets, which entirely eliminates the expense of circular form work required in many constructions. A few of the many appli-

cations in this field cover arched floors, tanks of all descriptions, silos, culverts, etc.

The development of this material has been such that there are now three distinct types of it with varying depths and spacing of ribs. These types are all manufactured from various gages of steel so that practically every condition of reinforcement and form work can be properly cared for. The methods of manufacture are very interesting, requiring an extensive equipment

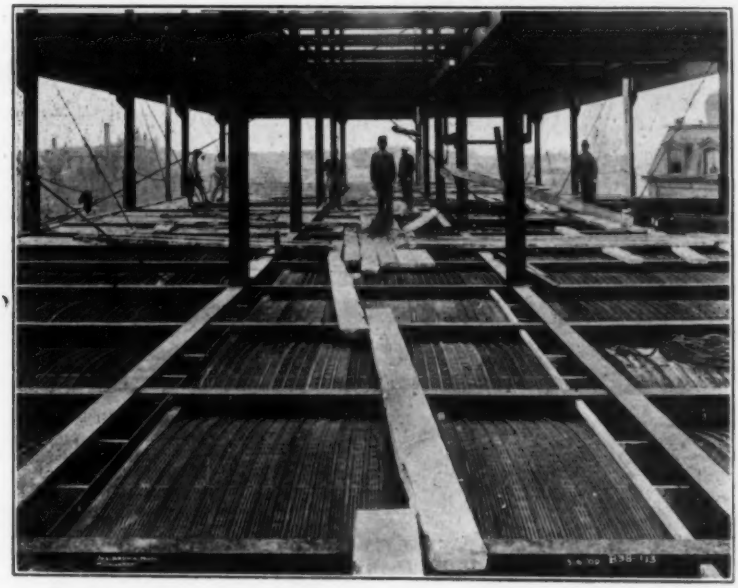


FIG. 3.—ARCHED FLOOR CONSTRUCTION.

and skilful handling. The steel plates are first cut the exact size required and are then put through pickling vats for a sufficient length of time to bring them to the exact condition required in their manufacture. The plates are then thoroughly dried and passed through the first forming press. After this operation they are punched under a very powerful press which cuts the sheets to an accuracy of one-ten-thousandth of an inch. The dies and cutting tools have been scientifically developed and are very complicated. The special cut sheets are then placed in the form-

ing press which by a process of compression and expansion forms the finished sheet. This one press has a capacity of 450 tons pressure at one blow, which fact gives an idea of the elaborate machinery necessary to manufacture this material.

There is no doubt that materials of this nature combining both reinforcement and forms represent the right ideas of development. Their tremendous success in all classes of construction has proven that they have filled a long felt want. Their use means greater economy, fireproofness, rigidity, and light weight structures.

The Y. M. C. A. Building, Mexico City, Mexico, after it had passed through the bombardment incident to the ten-day siege in February, 1913, was in the following condition: The galvanized iron cornices and terra-cotta copings were completely demolished, while the expanded metal construction was merely pierced by the shot and shell that had passed through the partitions and knocked off the plaster, but did not demolish the metal construction. New sheets of expanded metal were placed over the holes in the partitions and replastered. In this manner the building was repaired with a minimum expense.

DISCUSSION.

MR. C. A. AUTEN.—I confirm the answer of the previous speaker that not more than 5 per cent of the quantity of concrete applied will pass through expanded metal and be lost. I have seen many instances where expanded metal was used in floors upon which the concrete was poured (for example a bridge floor), and expanded metal was used in the side walls and plastered, in which less concrete had fallen through the floor metal onto the ground beneath the bridge than had been dropped by the plasterers. Mr. Auten.

MR. T. H. SKINNER.—I understand that in the floor construction described the metal lath is the form, and that on the side walls and partitions, the mortar is applied to the lath with a trowel. Have you any data that will show how durable walls made in this way are when used on the exterior of buildings? That is, are they really any better than ordinary "stucco walls" which are laid over metal lath, of square mesh small wire, with "V" or rod stiffeners? I have seen many examples of stucco work on expanded metal lath that has gone to pieces, due to the throwing off of the stucco through expansion of the metal from rust, but none on the kind of lath I mention. How are these constructions better than those we have used in the past? What means have you taken, or are you taking, to avoid these errors? Mr. Skinner.

MR. AUTEN.—A cement mortar plaster is used for side walls and partitions. The principal causes of failure of the construction you mention, were first, the lath itself (probably of a thin gage and more or less weak), and second, the fact that the stucco was on wooden studs or on a wooden framework. This wood, especially in a new building, will certainly dry out and shrink, which puts a stress in the stucco. In the construction illustrated the expanded metal is placed on steel posts, trusses or angle irons, spaced for the purpose. Then, also, the metal has ribs about every 7 in., which make it much stiffer than the lath usually used. Mr. Auten.

Mr. Skinner. MR. SKINNER.—I recognize the fact that the material described is much stiffer, but, the filling material is put on with a trowel, simply relying on the "elbow grease" of the mechanic to make it compact. I have seen stucco work, by the best workmen using the best materials, on buildings in eastern New England and New York, although it did not have the exposure of those described, that was in very bad condition at the end of 2 yr.; the work was done by the methods described to us, and I want to know whether you recommend it as a permanent construction for exterior walls, or whether you consider it should be used for temporary structures only?

Mr. Auten. MR. AUTEN.—I should say, yes, where you are placing the material on steel or other material that will not expand and contract, like wood. This material has been used for the last 6 or 8 years and it is in as good condition today as when it was put on. Trouble, however, has been encountered, due to the expansion and contraction of the concrete itself. The material was first used without reinforcing the concrete in both directions, and, in some instances, cracks formed parallel with the ribs of the lath. Now it is customary to place $\frac{7}{32}$ in. diameter rods, 18 in. on centers, at right angles to the ribs, thus reinforcing the concrete in both directions.

Mr. Boyer. MR. EDWARD D. BOYER.—To condemn stucco construction would be like condemning concrete construction because you have had failures. It is a fact that there have been a large number of stucco failures which have been due to the misuse and the abuse of the cement mixture as well as of the material on which it has been applied. But it is also a fact that in Canada, on the shores of Lake Ontario, and through New England, especially in the Metropolitan Parkway System and the different beaches, stucco construction has proved remarkably successful. There is no doubt, I believe, in any one's mind, that you can find any number of examples all over the country where stucco construction has proved permanent in every sense of the word.

The company with which I am identified, a short time ago wrote to a large number of architects who specialize in stucco construction, and found that the specifications used differed a great deal in the essential details. The American Concrete Institute is endeavoring to remedy this condition and probably

will succeed in doing so by adopting a uniform specification for stucco; but as long as architects in Boston, New York, Philadelphia, Los Angeles or Jacksonville continue to use specifications differing in essential details, the results will not be uniform. We have standard specifications for steel, and for cement; what we need is a standard specification for stucco that can be successfully used by architects all over the United States; then failures will not occur. Mr. Boyer.

MR. CLOYD M. CHAPMAN.—My company has used a large amount of expanded metal on the exterior of steel frame buildings, largely in roundhouses, shelters, repair shops, signal towers, and similar railroad constructions. We have had so many failures with this type of construction, due evidently to the corrosion of the metal, perhaps from a lack of protection by a sufficient thickness of stucco on the outside, that we have arrived at the conclusion that plain or painted metal must be imbedded at least 2 in. below the surface of a dense mixture of cement and sand, otherwise it must be galvanized. We have had a large proportion of failures in which the stucco or mortar scaled from the metal, and left a very badly corroded lath; it was quite evident that the cause of failure was the swelling or the increase in volume of the iron due to its oxidation, which forced the stucco from the surface. Mr. Chapman.

MR. LEONARD C. WASON.—I would like to ask the speaker whether the metal is used black or whether it is galvanized or painted? Mr. Wason.

MR. AUTEN.—Some specifications require it to be painted and some do not. Unless otherwise specified, we paint it, since usually the lath lies around before it is used; we do not know what is going to happen to the material after it is shipped before it is used in the work and it is well to protect it in the best possible manner. The lath is oil dipped but not baked. The cost of japanning is high. In regard to the thickness of the outside concrete walls; we recommend, in all cases, at least $1\frac{1}{2}$ in. of cement plaster on the outside of the metal; the rib is turned in and there is usually $\frac{1}{2}$ in. of plaster on this side of the metal. Where the metal is used for roofs or floors, the concrete is poured on and the slab usually runs from 2 to 4 in. in thickness, depending on the span and the load it has to carry. Mr. Auten.

Mr. Chapman. MR. CHAPMAN.—We have made a large number of experiments with plates of steel painted and imbedded in concrete, but have not yet found a paint that after being imbedded 3 months in concrete could fairly be called a paint. It had become a layer of powder whose protection against the moisture coming through the cement mortar was practically zero. It may be that the application of paint to reinforcing material serves some useful purpose in protecting it from excessive rust before it is put in place, but when it is in place paint is more of a detriment than otherwise. None of these tests were made with paints that were baked on. I have heard of materials that can be baked on that are said to withstand the action of moisture for a very much greater length of time.

Mr. Auten. MR. AUTEN.—The layers of paint that remain on reinforcing steel whether it is to be used in a roof or any other place, are certainly going to interfere with the bond of the concrete to the steel. You are placing a coating between the concrete and the steel, and that should be avoided. My idea in recommending the painting of expanded metal is to keep it in proper condition until it is placed in the work; and you have certainly to depend on the workmanship and the waterproofness of the concrete to keep it in condition after it is placed in the concrete.

Mr. Brown. MR. BURTIS S. BROWN.—I would like to ask if any trouble has been experienced with this metal rusting in the floors of buildings where there is water, such as cold storage buildings; and if so, what precautions are taken to prevent it?

Mr. Auten. MR. AUTEN.—I do not know of any trouble of this nature occurring in that kind of a building.

Mr. Parry. MR. O. R. PARRY.—My experience as an architect is that expanded metal used in stucco on the exterior of buildings along the seashore is unsatisfactory; if used for reinforcing concrete it is satisfactory. In my own practice we are very chary about using it in exterior work, and I have found that I can get better results with wooden lath than with expanded metal for stucco work; the reason being that there is an air space between the sheathing and the lath; if the plaster is weak in any spot the moisture and the weather enters there, and rusts a metal lath. If our friends could produce a lath that will withstand that action of the weather, they would be giving us something we badly need.

MR. P. H. CLARK.—I would like to ask the gentleman why he did not follow the recommendations of this Institute for stucco that have proven very satisfactory and have resulted in successful work? Mr. Clark.

MR. PARRY.—There is a very good reason. I know that expanded metal protected by a one inch covering of mortar will be satisfactory. But you do not have to do that if you use wooden lath; and in seashore work you certainly have a very quick corrosion of your metal unless it is protected. The cost is an important factor. Mr. Parry.

MR. H. B. MCMASTER.—I would like to suggest to Mr. Parry, supplementing what Mr. Clark has said, that this Institute has developed a standard specification that solves his problem. With reference to the exposure of stucco on the seashore, there are in New England many examples of successful stucco work, some right at the edge of the water. Every architect in Boston who has anything to do with stucco work will, I am sure, bear me out in the statement that any metal lath, let it be wire or expanded metal, if back plastered—as the Institute specification requires, is protected absolutely against corrosion, and I will bear out what has been said about painting simply to prevent initial corrosion. The cement, and what little lime there is in the mix is a preservative of the steel. I should say that is all that is necessary. Mr. McMaster.

MR. W. F. TUBESING.—What would you say of an interior partition that in 5 years would be completely rusted? Was there something in the plaster or stucco that caused it? I know of interior partitions where you can put your hand through the metal reinforcement; instead of a ribbed metal lath, a small channel to give greater stiffness was used. Mr. Tubesing.

MR. MCMASTER.—The Metal Lath Association has sought conscientiously for all data bearing on the corrosion of iron and steel that goes into a building whether it be structural members, water and gas pipe or metal lath. When we have been able to find examples of disintegration we have studied the circumstances carefully, have had the plaster analyzed and endeavored to find a fundamental cause; nearly all cases where there has been disintegration of metal lath, have shown traces of calcium sulphate. That brings us into the patent plaster field. I may Mr. McMaster.

Mr. McMaster. be treading on dangerous ground but I do not hesitate to say that this material is dangerous when in combination with moisture. Personally I have had the opportunity of investigating quite a number of cases where there has been disintegration of metal lath, and we have been able to find the cause in nearly every case. Now the country is full of lath construction to which patent plaster has been applied. In New England we are able to say that there are perhaps 25 or 30 million yards of metal lath standing today. A great deal of that is in connection with patent plaster but apparently with little or no moisture after hardening. Some of this lath has been on 25 or 30 years, but it may be stated, that while the gypsum plaster may disintegrate when water reaches it, cement thrives on water which accounts for the tendency to prefer the cement mixture in some places where it comes in contact with steel. I would say that the patent plaster is not inimical to steel. But when a sewer or a water pipe breaks in your walls, the patent plaster disintegrates from the moisture and very soon reaches the metal which goes very quickly.

Mr. Tubesing. MR. TUBESING.—The case to which I refer happened to be in a very dry place; in an interior stairway and I was surprised at the condition of the expanded metal lath. After 5 years it was just like so much powder. In drafting a specification, these things will have to be investigated in order to find out what is the cause of failure. If we are going to write these specifications they must be fully proved. In using this type of wall, in some cases, we have to guarantee it for a certain period of time and therefore must be sure the work is properly done

PROGRESS AND DEVELOPMENT OF CONCRETE WORK ON THE DELAWARE, LACKAWANNA AND WESTERN RAILROAD.

By A. B. Cohen.*

A brief review of a few historical facts concerning the road itself is essential to a better understanding of the progress and development of concrete work on the Delaware, Lackawanna and Western Railroad.

The Lackawanna Railroad at its inception was built to transport coal from the anthracite region around Scranton, Pa., to the seaboard. A line was projected eastward as early as 1850. Like the few other roads of that day, it lacked financial strength, and since the country through which it necessarily extended was at best exceedingly rugged and mountainous, the management was compelled to follow the line of least resistance rather than the direct route toward the coast. The road was built in a southeasterly direction from Scranton over the Pocono Mountains and through the Delaware Water Gap to Portland, Pa., a point on the river a few miles below the Gap, by the parent company and from this point to Hampton, N. J., by a leasing line, the Warren Railroad Company. These lines were 61 and 21 miles in length respectively.

At Hampton the greater part of the coal was delivered to the Central Railroad of New Jersey for transportation to tide-water, and at Washington, N. J., a portion was transferred to the Morris Canal, then in the height of its activity, for transportation to Paterson, Newark and other towns along its route.

At Washington, the Warren Railroad crossed the line of the old Morris and Essex Railroad extending from Hoboken to Phillipsburg on the Delaware River. In 1860 this road was leased by the Delaware, Lackawanna and Western Railroad, and in this way the latter company obtained a through line from the coal fields of Pennsylvania to tide-water at New York.

*Assistant Engineer in Charge Concrete Design, The Delaware, Lackawanna and Western Railroad, Hoboken, N. J.

Previous to this, however, about 1852, the line was extended westward from Scranton to a point near Binghamton, N. Y., where connection with the Erie Railroad made possible western shipments. In 1869, by the purchase of the controlling interest of stock of the Syracuse, Binghamton and New York Railroad, operating between Binghamton and Oswego on Lake Erie, the Delaware, Lackawanna and Western Railroad obtained an opening to the Great Lakes. This line, in 1881, gave way to the Buffalo extension from Binghamton as the main line.

The combination of these various lines, built independently of each other in the early days of railroad construction, necessarily resulted in some very heavy grades and many detours.

With the advent of an entire new management in 1889 under the direction of President Truesdale, it was soon determined that extensive improvements at a number of points were necessary for a more economic operation. Traffic had increased far beyond the expectations of the original builders, which might be said of all the earlier railroads. While the motive power and equipment followed in a measure the advancement of the day, nevertheless the heavy grades and roundabout routes made operating very expensive. Gradually improvements were made which resulted in a highly developed system embodying the best practice of railroad construction and equipment. Concrete has played a very important part in this development by reason of the facility and the rapidity with which it can be placed; these have so expedited the construction of structures necessary in improvements of the magnitude of those made by the Lackawanna Railroad, that it can be safely asserted that the use of concrete has made possible these economic changes. This can readily be understood by description of these various improvements and the uses that have been made of concrete showing its progress and development.

NEWARK TRACK ELEVATION AND DEPRESSION.

The first improvement of importance made by the new management was the elimination of grade crossings and reduction of grades through Newark, N. J., in 1903 to 1905. This line

through Newark had long since given way to the Boonton Branch through Paterson as the main line, but it tapped the highly developed New Jersey suburban district. A maximum grade of 138 ft. per mile made operation of even suburban trains very difficult. By restoring to part track elevation and part depression, this grade was reduced to 60 ft. per mile. All the bridges were built of structural steel, but concrete was used extensively for the first time by the Delaware, Lackawanna and Western Railroad in the construction of the retaining walls (see Fig. 6).

About the time of completion of this work, the Hoboken Terminal and several docks burned down. In the reconstruction, concrete was used to great advantage in the docks carrying engine loading. This work consisted of a grillage of piles driven over the entire area carrying a solid floor of 12 by 12 in. at mean low water. A cinder fill over this floor, suppporting track laid in the usual manner, was retained by massive concrete bulkhead walls. Practically the first reinforced concrete was used in roof and floor construction of the railroad shop built at Kingsland in 1903, but the most extensive use of reinforced concrete in building construction was made in 1906–1908 when the Scranton shops were built. Brick was used for the walls of all the buildings, but the frame work of a number of them was constructed of concrete and it was used in subway construction of great length, in storage bins and large foundry casting platforms.

NEW JERSEY CUT-OFF.

Starting from the eastern terminal, the main line crossed the State of New Jersey by a very circuitous route. It was 85 miles by rail, while the air line distance is but 58 miles. A ruling gradient of 1.14 per cent uncompensated over the western half of the state necessitated the use of pusher engines for heavy traffic. The heavy grade, together with the roundabout route, made operation very expensive. To improve this condition, a cut-off line was located, in 1905, between Hopatcong and the Water Gap. By resorting to very heavy construction, crossing the drainage of the country at right angles, it was possible to establish a ruling compensated grade of 0.55 per cent, or 29 ft. per mile. The following table, showing the physical character-

istics of the old and new lines, will give an idea of the character of the work:

	OLD LINE.	NEW LINE.	SAVING.
Distance, miles	39.57	28.45	11.12
Maximum grade, ft. per mile	68	29	39
Number of curves	57	15	42
Maximum grade	6 deg. 54 min.	3 deg. 36 min.	3 deg. 18 min.
Total degrees	2,000	440	560
Rise and fall, ft	248	11	237

The saving of this new line, based on the actual cost of operation, maintenance of roadway, structure, repairs, etc., war-

FIG. 1.—SIGNAL TOWER AT HOPATCONG, N. J.

ranted the expenditure of $11,000,000, the cost of the improvement. The cost per mile is $387,000. This work gave the real impetus to concrete construction on the Delaware, Lackawanna and Western Railroad. With one exception, all of the 70 bridges were built of concrete, which required 260,000 cu. yd. The largest structures are the Paulins Kill and the Delaware River Viaducts.

SIGNAL TOWER.

The first structure on the cut-off line is the concrete signal tower (Fig. 1) at Hopatcong, the junction of new and old lines.

The walls are paneled and bush-hammered to relieve the otherwise plain surfaces. The roof is glazed tile. This tower was built by company forces and is of the type adopted as a standard.

RAILROAD BRIDGES.

All the highways crossing the cut-off line have been carried either under or over the tracks by arches or reinforced flat-top bridges. The Hopatcong Road arch, shown in Fig. 2, represents the best type of this construction. Some attention was given its appearance, since it spans a much-traveled county turnpike. The semi-circular arch, however, of 20, 24 and 30 ft. spans, was

FIG. 2.—HOPATCONG ROADWAY ARCH, MUSCONETCONG FILL.

the general type used on the new line. These arches were built under varying conditions—on piles, earth and rock foundations, under fills to depth of 110 ft.; on steep highway grades, and there were many skew arches, some of which were built on an angle of 45 deg. with the center line of track. Similar conditions prevailed for culverts carrying water courses.

COMBINATION HIGHWAY ARCH AND CULVERT.

The greater height of fills made it economical to divert streams for comparatively long distances to highway arches so that one structure would carry both highway and stream. The road is

carried over the stream on a reinforced concrete slab, the abutments of the arch serving as side walls for the culvert. The culvert has a reinforced-concrete invert built simultaneously with the arch abutments, thus preventing the undermining of the abutments by the scouring action of the stream. The box formed between the abutments furnishes a brace should settlement occur which might tend to collapse the arch.

FLAT-SLAB BRIDGES.

Where the vertical clearances were limited, flat-slab bridges were built in spans of 20 and 24 ft. The problem in designing

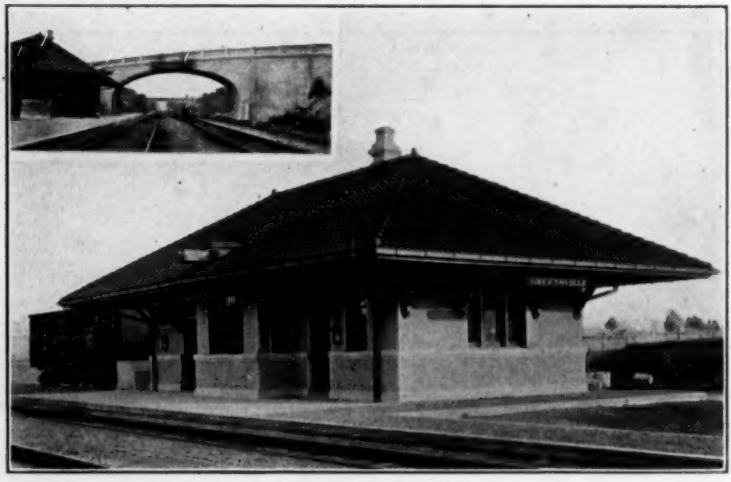


FIG. 3.—GREENSVILLE STATION.

these bridges on a skew was solved by reinforcing the slab on the right span and the parapet wall to act as a girder carrying the triangular or skew portion of the floor. The slab and parapet girders were built in continuous operation.

OVERHEAD HIGHWAY ARCHES.

The highways are carried overhead on reinforced-concrete arches of the elliptical type. The span for arches normal to the track was made 56 ft., giving clearance for four tracks; rise 12 ft.

6 in.; crown thickness 1 ft. 6 in. The Greensville arch shown in Fig. 3 has a skew angle of 45 deg. It was designed for a skew span and constructed in laminæ parallel with the center line of the highway. To eliminate any tendency of the ring to slide, the abutment skewback was formed in offsetted inclined planes normal to the pressure line of the arch.

STATIONS.

Previous to the cut-off work a number of stations were successfully built of concrete; it was therefore decided to construct the three stations on the new line in similar manner, adopting the pleasing effect obtained with signal tower design resulting from the combination of bush-hammered concrete and glazed tile roof. The Greensville Station is shown in Fig. 3.

PEQUEST RIVER DOUBLE-BARREL ARCH BUILT ON GRAVEL FOUNDATION UNDER 110-FT. FILL.

The line crosses Pequest Valley on a fill 3 miles long, averaging 75 ft. in height and containing 6,625,000 cu. yd. of earth. The maximum height of the fill is 110 ft. Next in importance to the Delaware River and Paulins Kill viaducts, is the Pequest River arch through which the river flows under the deepest part of this embankment.

Soundings at the site showed a 30 ft. stratum of gravel with varying amounts of clay and fine sand. At intervals large boulders were encountered, making the driving of piles impossible. A 40-ft. arch was proposed, but under the heavy fill the maximum pressure on the foundation was found to be far in excess of the safe carrying capacity of the soil. This being impracticable, the alternative was a 20-ft. twin arch. Even with this construction, very large abutments would be necessary to keep the maximum toe pressure under 6 tons per sq. ft. Further investigation showed a heavily reinforced invert or mat foundation to be not only more stable but less expensive. By reason of this design the base of the foundation could be placed just below the surface of the gravel, with no possibility of it being undermined by the water, as might be expected if the abutments were independent of each other. The length of the arch is 309 ft. In determining the dead load on

the arch, no allowance was made for any arching action of the fill. The weight of the total fill above the top of the arch was taken at 100 lb. per cu. ft.

To keep the same working stresses for the steel and concrete and to obtain as nearly as possible a uniform pressure on the foundation, the ring, abutments and inverts were decreased in four sections from the middle to the face of the barrel. The middle section was designed for the maximum fill of 90 ft. over the crown, and the remaining sections were designed for the ver-

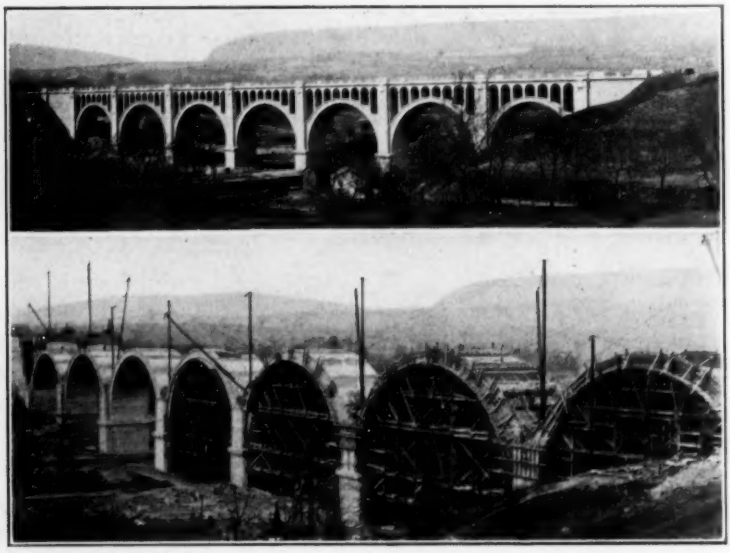


FIG. 4.—PAULINS KILL VIADUCT, HAINESBURG, N. J.

tical fill over each as determined by a slope of $1\frac{2}{3}$ to 1. The total load transferred to the pier and each abutment was approximately equal, making the pressure on the base about uniform. On the middle section this amounted to 5.6 tons per sq. ft. and the slab for the invert was designed to resist this pressure. The structure contains 10,950 cu. yd. of concrete and 520,000 lb. of reinforcing steel.

PAULINS KILL VIADUCT.

The second largest structure on the cut-off line is the Paulins Kill viaduct at Hainesburg, N. J. It is a double-track bridge

100 ft. long, 34 ft. wide and 117 ft. above the water, consisting of five 120- and two 100-ft. full centered arches with crown thicknesses of 6 ft. and 5 ft. respectively. All the piers are carried to rock, the depth of which varies from a few feet below the surface at the abutments to a maximum of 30 ft. at the center pier.

For construction a mixing plant was located close to the viaduct site, from which concrete was hauled in one-yard buckets on narrow-gage trains to the various derricks for distribution. The first position of the derricks was on the ground near each pier, where they remained until the piers were completed to the springing line. Next they were raised to their second position upon steel I-beam towers erected upon each pier. From this position all the concrete in the ring was poured. The ring was cast in blocks and keys placed in position to uniformly load the timber centering. At least 7 days were required to elapse between the pouring of any block and the adjacent key, and 28 days after the last key was completed the centering was lowered. This method was used so that the shrinkage might have little effect upon the finished ring. The derricks were finally placed upon the top of the two center spandrel arches which were poured from the second position. From this final position the remainder of the floor system was completed. Fig. 4 shows the various stages of construction together with a view of the completed structure.

The abutments are of the "U" type with three longitudinal reinforced-concrete walls supporting a reinforced slab to carry the roadway. The embankment was allowed to take its natural slope between the walls, tied together with reinforced-concrete struts, as was the case on the outside of them.

Surmounted on the main arches, the superstructure consists of a series of transverse spandrel walls and arches. The true arch action was here destroyed by pouring the top of the arches to a level surface to form the floor on which the track was laid over 3 ft. of rock ballast. The floor is waterproofed by a membrane composed of four layers of felt and five layers of asphaltic compound. This is protected by a layer of brick, grouted and covered with the compound.

In the construction of the viaduct there was used 43,200 cu. yd. of concrete and 735 tons of reinforcing steel.

DELAWARE RIVER VIADUCT.

The largest structure on the cut-off line is the Delaware River viaduct at Slateford, Pa. (Fig. 5). It is a double-track bridge 1,450 ft. long and 64 ft. above the river. It consists of five 150-ft. and two 120-ft. elliptical arches, rise 40 ft. with crown thicknesses of 6 ft. 0 in. and 5 ft. 4 in. respectively; also two 33-ft. full centered arches. The two smaller arches and one 120-ft. arch on the west end are on a 3 deg. 36 min. curve and this, together with a skew angle of 25 deg. for the remainder of

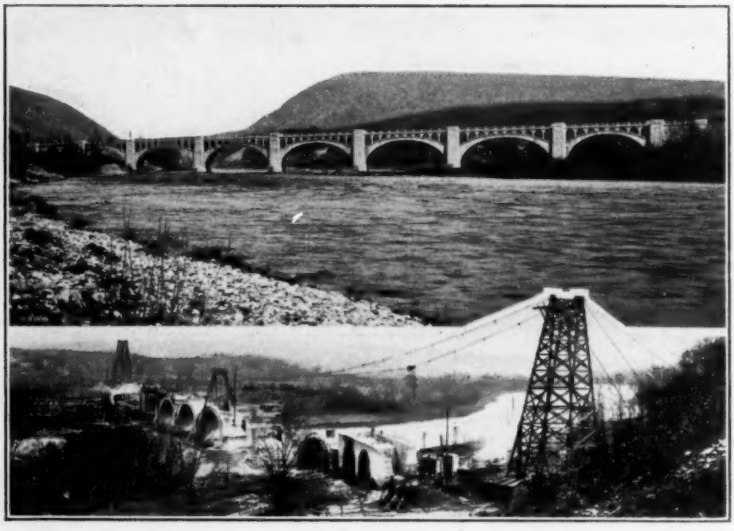


FIG. 5.—DELAWARE RIVER VIADUCT, SLATEFORD, PA.

the structure, made the construction more difficult than that of the Paulins Kill viaduct.

The rock stratum is comparatively level, but because of the unevenness of the ground the depth ranged from 25 to 53 ft. The construction was carried on by means of a traveling cableway suspended over the center line of the viaduct, and supported from timber towers on either bank, approximately 2,400 ft. apart. Midway between these towers an A-frame mounted upon two large temporary piers furnished the intermediate support and divided the cableway into two working units. (See Fig. 5.)

A mixing plant was established on each side of the river directly beneath the cableway. With the longest haul each plant had a capacity of 250 cu. yd. per 10-hour day. Little difficulty was experienced in driving ordinary timber sheet piling. The material excavated for piers was gravel and boulders. Contrary to expectations, the gravel formed an almost impervious obstruction to the water. One pump was able to take care of the leakage into the pier excavation.

Steel centering was used in the construction of the 150-ft. arches. This centering was composed of ten separate 3-hinged arches spaced 4 ft. centers and braced laterally to form a rigid unit. The ribs were supported by short structural steel columns placed upon an I-beam grillage which rested upon an offset of the pier foundation. The centering was lowered by means of a double toggle joint at the crown panel, by which the two vertical members were lengthened or shortened for lowering or adjusting the centering. Similar to the construction of other skew arches, the skew backs of the piers were formed in six offsetted inclined planes normal to the pressure line of the arch ring.

The U-shaped retaining walls of the east abutment are a feature of the design. They consist of two heavily reinforced walls 3 ft. thick at the top and increasing on a uniform batter to 1 ft. 5 in. at an elevation which is approximately one-third of the height of the walls. At this point of resultant earth pressure, reinforced struts 1 ft. 10 in. x 3 ft. 0 in. spaced 5-ft. centers connect the two walls with sufficient steel to resist the horizontal thrust. Above the struts the walls were reinforced for cantilever action. The footing course is continuous under both walls. Total height of wall is 57 ft. The combined weight of the U walls (on earth foundation) and fill resists the horizontal thrust from the adjacent 120-ft. arch. The vertical load of the arch is carried to rock on two 9 x 40-ft. caissons.

The floor of the viaduct was waterproofed with two layers of an asphaltic compound applied hot and bound by two layers of very light cloth fabric. This coating, about $\frac{3}{16}$-in., was protected by 2 in. of concrete. There are no expansion joints in the floors of the Paulins Kill and Delaware River viaducts, the longitudinal reinforcing steel being continuous.

The Delaware River viaduct contains 51,400 cu. yd. of con-

crete and 627 tons of reinforcing steel. The work was begun August, 1908, and was completed three years later.

MONTCLAIR IMPROVEMENT.

Another improvement is the complete revision of the Montclair Branch, 4 miles in length, extending from Newark to Montclair. The line, which for the most part was a single track, has been double tracked, and all the grade crossings have been eliminated. New stations have been built at Watsessing and Bloomfield, sundry improvements at Glen Ridge and the Montclair Terminal has been reconstructed.

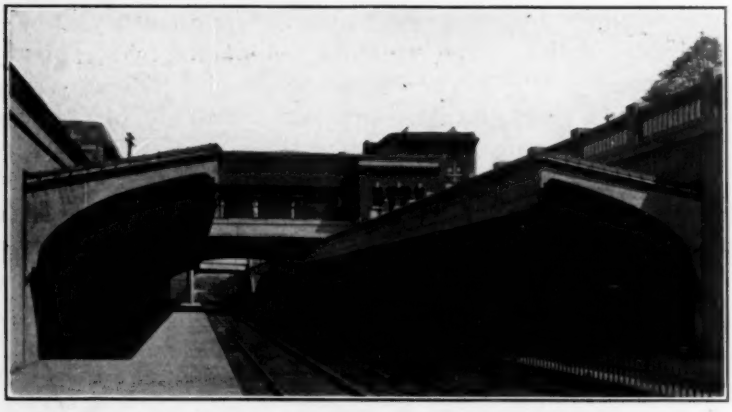


FIG. 6.—WATSESSING AVENUE STATION, BLOOMFIELD, N. J.

This line takes care of a very large suburban traffic to and from New York City, which is 15 miles from Montclair. In addition the branch also handles a very large milk and ice business and serves a large number of industries.

Because of limited right of way through Watsessing, the reconstruction followed along the old line. In making the depression a trench was excavated in which the retaining walls on one side were constructed without removing the tracks or delaying the traffic. After its completion, the tracks were shifted over beyond the walls, the depression was then made and the other wall built. These retaining walls are of gravity type built on rock in alternate sections of 20 ft. in length without any hori-

zontal joints. The drainage beyond the walls is taken care of by blind drains of loosely piled stone, placed at each construction joint and extending from the base to the full height of the wall. Weep holes were placed at the lower ground line for each drain.

Watsessing Avenue Station, shown in Fig. 6, was built directly over the tracks. The building faces the avenue which is carried over the railroad on an elliptical arch. The station is supported on four reinforced-concrete arch girders with intradosal curves similar to the arch carrying the roadway. A 4-in. concrete ceiling was built between the girders to give the appearance of a con-

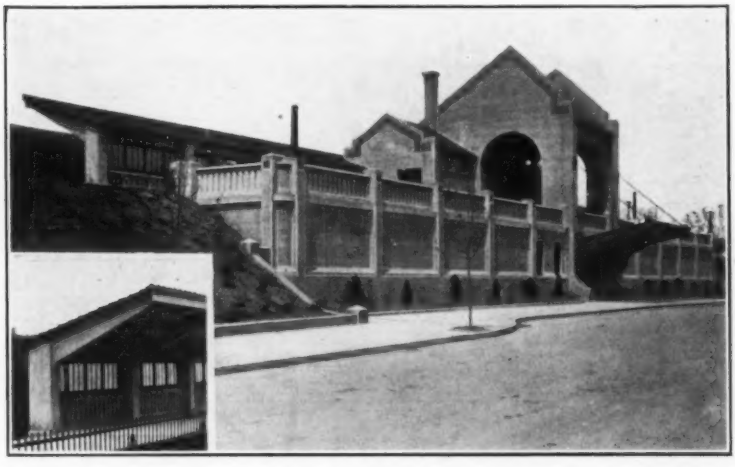


FIG. 7.—STATION, BLOOMFIELD, N. J.

tinuous arch. The canopy is also reinforced concrete. The brackets are cantilevered from the retaining wall, the base of which is widened to take the increased overturning moment.

The new Bloomfield Station (Fig. 7) was built of concrete bush-hammered and decorated with green tile. Here also the canopies are of reinforced concrete, but instead of being supported from retaining walls they are carried on columns of an elevated platform. The fill was made to the top of the platform beams, after which the concrete slab was built without forms. Clearance requirements necessitated the use of structural steel through girder bridges for two crossings. Glenwood Avenue and Washington

Street adjacent to the Bloomfield station. These were entirely encased in concrete to conform with the architectural features of the station; Glenwood Avenue bridge is shown in Fig. 8.

Montclair with a population of about 25,000 is the terminus of this branch. It is situated on the slopes of the Orange Mountains and this location, together with its close proximity to New York City, makes it a very attractive residential section. Many influential people are numbered among the inhabitants. The old station was served by one track and a turn-table. To accommodate the heavy daily morning traffic to New York City it was necessary to store the passenger cars over night at the terminal, and this storage room was crowded on three stub tracks over

FIG. 8.—GLENWOOD AVENUE BRIDGE, BLOOMFIELD, N. J.

which the freight and milk business was also handled. The new layout provided for six tracks, and the area formerly occupied by both freight and passenger facilities is now entirely devoted to the passenger terminal shown in Fig. 9. The new station is built of tapestry brick trimmed with artificial stone made of concrete which is faced with terazza chips exposed by a wash finish. The structural steel umbrella shed has a concrete roof slab covered with flat tile laid in asphalt. In the background can be seen Grove Street viaduct (reproduced in insert), which is of the T-beam design with spans of 36 and 38 ft. Reinforced-concrete stairways lead from the bridge to the platform and station grounds. The kiosks, pilons and balustrade are all of concrete.

Several retail coal trestles were displaced by this layout. The coal business was centralized in one large pocket shown in Fig. 10. This is of cantilever type built of reinforced concrete. The partition walls, the lower portion of which form the cantilevers, divide the coal pocket into twelve bins.

The cross-section of the bin floor is similar to the letter W. Coal can be drawn simultaneously from three gates of each bin, from two under the cantilever portion and from one over the driveway between the columns. The capacity of the pocket is

FIG. 9.—STATION, MONTCLAIR, N. J.

3,000 tons. It is fed from the two tracks and is sheltered by a timber and corrugated metal shed. The approach to the pocket is on a concrete trestle.

CLARK'S SUMMIT-HALLSTEAD CUT-OFF.

Going back to the main line, it is found that there is but one point where a railroad east of Scranton can pass the barrier imposed by the rugged range of the Kittatinny Mountains, and that is at the Delaware Water Gap where, in ages past, the Dela-

ware River cut its way through the range. It is impossible to shorten the line between Scranton and the Water Gap. Scranton is located in a deep valley with rising grades on all sides, and the reduction of the grade on this section would require excessive length and curvature.

The improvement known as the Clark's Summit-Hallstead Cut-Off, which involves some of the heaviest railroad grading and concrete bridge work ever undertaken, extends from Clark's Summit, 7 miles west of Scranton, to Hallstead, Pa., about 14 miles east of Binghamton, N. Y. In the 39.6 miles of the new

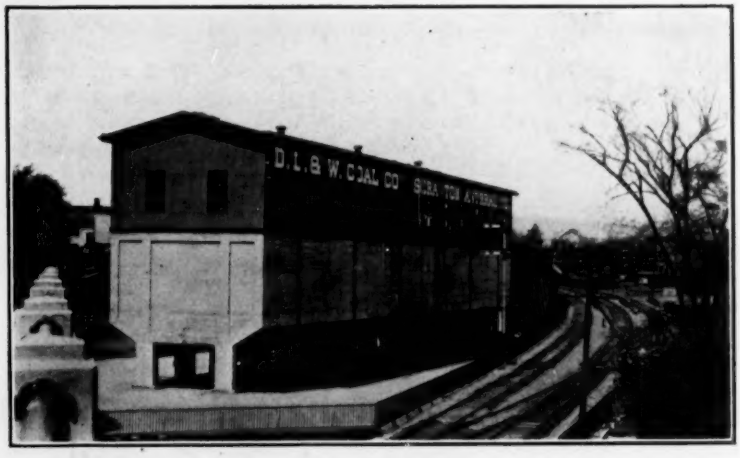


FIG. 10.—COAL POCKETS, MONTCLAIR, N. J.

line the excavation quantities are 5,525,000 cu. yd. of earth, 7,647,000 cu. yd. of rock and 146,000 cu. yd. tunnel excavation.

PHYSICAL CHARACTERISTICS OF THE OLD AND NEW LINE.

	OLD LINE.	NEW LINE.	SAVING.
Distance, miles	43.2	39.6	3.6
Maximum grade EB, per cent	1.23*	0.68	0.55
Maximum grade WB, per cent	0.52*	0.23	0.28
Maximum curve	6 deg. 22 min.	3 deg. 00 min.	3 deg. 22 min.
Total degrees	3,970	1,570	2,400
Degrees per mile	91.2	37.9	53.3
Rise and fall, feet	553.0	226.0	327.0

*Uncompensated.

Approximately 300,000 cu. yd. of concrete will be used in the construction of the two large viaducts and in eighty minor structures. Some of the minor structures are being built under extraordinary conditions: an arch is being erected over a highway on a 15-per-cent grade; an overhead highway arch springs about midway down the sides of an 80-ft. rock cut; the south branch of the Tunkhannock Creek will be carried through an embankment 145 ft. high, 480 ft. wide at the base. This is the largest fill on the line and will contain 1,600,000 cu. yd. At the original location of the creek the rock was 50 ft. below the surface. To obtain suitable foundations for the culvert the creek was diverted by a considerable amount of excavation farther up the hillside, where the rock at the elevation of the flow line of the creek was close to the surface. The structure has two 24-ft. openings and will be 470 ft. long.

TUNKHANNOCK CREEK VIADUCT.

The two largest structures on this work are the Tunkhannock and Martin's Creek viaducts, which, when completed, will be the largest concrete structures of their kind.

The Tunkhannock viaduct, the larger of the two, is being built at Nicholson, Pa., 22 miles west of Scranton. It is a double-track bridge 2,375 ft. long and 240 ft. high above the creek, consisting of ten 180-ft. and two 100-ft. full-centered arches. All piers are carried down to rock, which is reached at a depth of from 10 to 95 ft. below the ground surface, making a difference of 300 ft. in elevation between bed rock and top of parapet at the deepest pier.

The piers are 36.5 x 43.5 ft. above and 40 x 46 ft. below the ground. The foundation for six piers was excavated, three to the ground-water line and three to rock, by a one-yard steam shovel. The shovel dug its way through the sand and gravel from pier to pier and the material excavated was used for the bed of a narrow-gage construction track. The other piers were built in open excavation sheeted with interlocking steel piling driven by a steam hammer.

The deepest foundation required two lengths of 30 ft. sheeting. First, an enclosure was driven for the full length of the piling about the outside of the lower diameters of the pier and

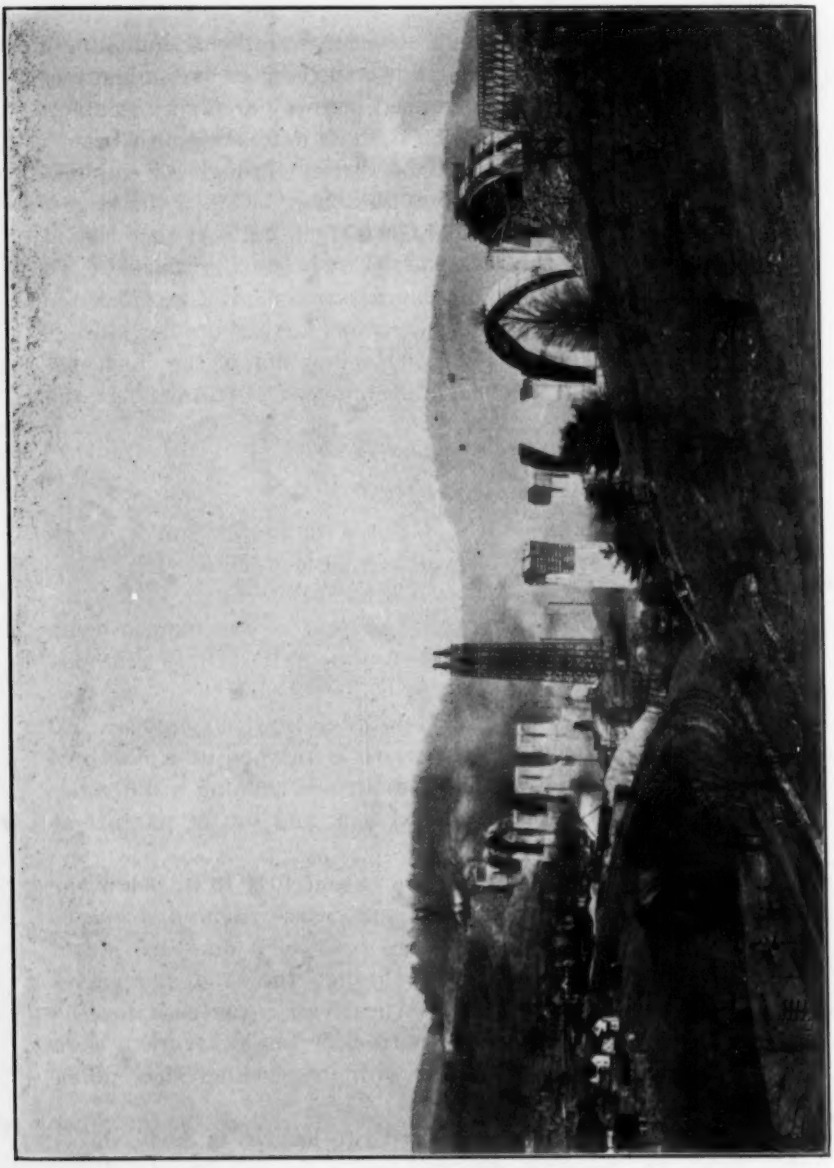


FIG. 11.—BIRD'S-EYE VIEW TUNKHANNOCK CREEK VIADUCT, NICHOLSON, PA.

the excavation was carried down with the driving. Next, another enclosure was started about 5 ft. outside of the first, after which both were carried down together as the driving progressed. The bracing for the upper or outer enclosure was entirely above the lower, so there would be no interference between the two sets of bracing. During the placing of concrete in the pier the water was collected and carried by drains to a sump in which pumps were located. In this manner, no concrete was placed under water. The pipe line from the pumps can be seen in the far right-hand corner. The footings carried to the bottom of the neat work were placed without forms. Tar paper was placed against the steel sheeting and the entire cofferdam, excepting the sump, was then filled with concrete. The sump was next concreted. The piling was drawn with an eight-part tackle hung from an A frame. The force applied was 40 tons.

Figure 11 shows bird's-eye view of viaduct in construction. The contractors' material siding off the present main line can be seen in the left-hand corner. The material is being handled by derricks from storage piles to the mixing plant located alongside and from the mixing plant to points beneath the cableway over the center line of the viaduct on the narrow-gage construction tracks previously mentioned. The end towers supporting the cableway are 150 and 165 ft. high and 3,028 ft. apart. The intermediate tower is 260 ft. high and 40 x 60 ft. at the base. On account of the long distance between the engine houses (located at the end towers) and the points of loading and unloading along the cableway, a complete telephone system was installed. The operators, provided with head sets, received directly all the signals from the men at the dumping points.

The pier forms are built in sections 17 ft. 9 in. high and four lifts of concrete are laid before raising them. The framing of the forms is of 8 x 10-in. and 6 x 8-in. timbers with two opposite diagonal layers of 1-in. sheeting faced with galvanized sheet iron. On the inner faces of the forms, strips of molding are placed at 4-ft. intervals to form the construction joints and the horizontal scorings around the pier. A 4-ft. lift contains 235 cu. yd. of concrete which must be run in one operation. The forms are braced by a system of 3.5 x 3.5-in. angles set in the concrete after every 4-ft. lift. The connection with the forms is made by turnbuckles.

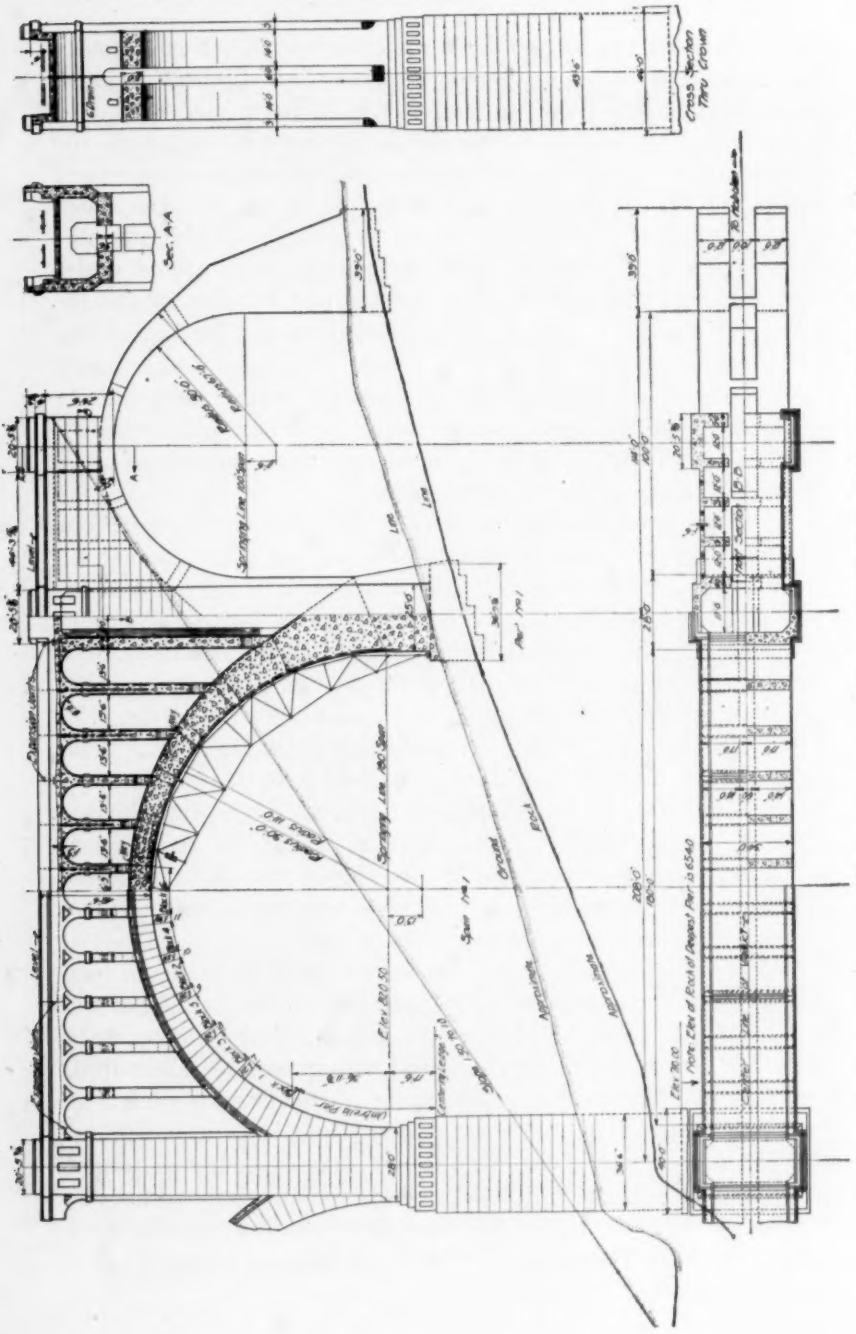


FIG. 12.—DETAIL DRAWING OF 180-FT. ARCH AND 100-FT. ABUTMENT SPAN, TUNKHANNOCK CREEK VIADUCT.

A detail drawing of 180-ft. arch and 100-ft. abutment span is shown in Fig. 12. The section at the right is through the crown of the main arch. This arch is divided into two ribs 14 ft. wide and 6 ft. apart. The crown thickness is 8 ft. The centering is steel similar to that used in construction of the Delaware River viaduct. The width of the pier at the springing line is 28 ft.; 17.5 ft. below the springing line the width of the pier is increased 4 ft. 3 in. on each side. The centering is supported on this ledge. The panels and steps shown on pier to the left covering the centering ledge will be built on sides of the pier after the centering has been removed. The 6-ft. openings between the ribs facilitate the moving of the centering by cableway to the next span. The superstructure on the main arch is composed of eleven 13 ft. 6-in. transverse spandrel arches. The floor is ramped from the crown of each arch to the center of the spandrel walls through which the drainage will be carried in 6-in. cast iron pipes to the opening between ribs.

An examination of the Delaware River and Paulins Kill viaducts, after they had been in service for some time, disclosed the fact that transverse cracks had formed at the crown of each of the two spandrel arches adjacent to each pier of the viaduct. This indicated that there had been a drop of the main arch rings due to fall in temperature. Over the crown the spandrel arches were in compression and no cracks developed while those adjacent to the pier were in tension. It may be here noted that the floor system was built during the summer months and therefore the movement in the main arch ring due to rise in temperature would bring the floor system back to its normal position, or, if there were a movement beyond this it would be so slight as to make its effect on the floor system directly over the crown negligible compared with the effect of a fall in temperature on the floor adjacent to the piers.

In view of the above observation it was decided in designing the Tunkhannock and Martin's Creek viaducts to place expansion joints at the pilaster and quarter points of each span. A floor system similar to that of the main arches will be continued to the center of the abutment span. The fill covers the other half and slopes through the hollow superstructure, completely concealing the abutment arch. The heavy approach fill will not come upon the back of the last main arch.

In construction the rings are carried up 43 ft. above the springing line with sectional timber forms before the erection of the steel centering. The centering is erected by bolting the upper and lower sections together, and until the placing of the opposite half are held in cantilever by bolts through the top of the umbrella pier assisted by cable guys anchored to the adjacent pier. The heaviest section weighs about 14 tons; capacity of each cable is 10 tons. The precautions that were taken by building the arch rings of the Paulins Kill viaduct in block and keys to load the centering uniformly and minimize settlement due to shrinkage will be repeated in the construction of the Tunkhannock and Martin's Creek viaducts.

During the process of preliminary design, when study was

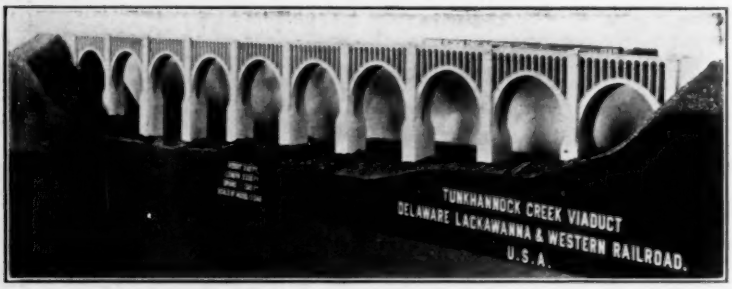


FIG. 13.—MODEL OF THE TUNKHANNOCK CREEK VIADUCT.

being made of the relative merits of structural steel versus concrete construction for this viaduct, the writer with his assistants undertook the making of a wooden model of the concrete design on a scale of 1 to 240, to better study the proportions of the structure. A photograph of the model is shown in Fig. 13. The result of this work was to dispel all doubt concerning unbalanced proportions and reduce the study to structural and economic considerations.

When completed the Tunkhannock viaduct will contain 167,000 cu. yd. of concrete, which is classified in three grades known as "A," "B" and "Cyclopean." Class "A" is a 1 : 2 : 4 mixture used in the reinforced superstructure of abutment spans. Class "B" is a 1 : 3 : 5 mixture and used in rings and superstructure of main spans. "Cyclopean" is the same mixture as "B"

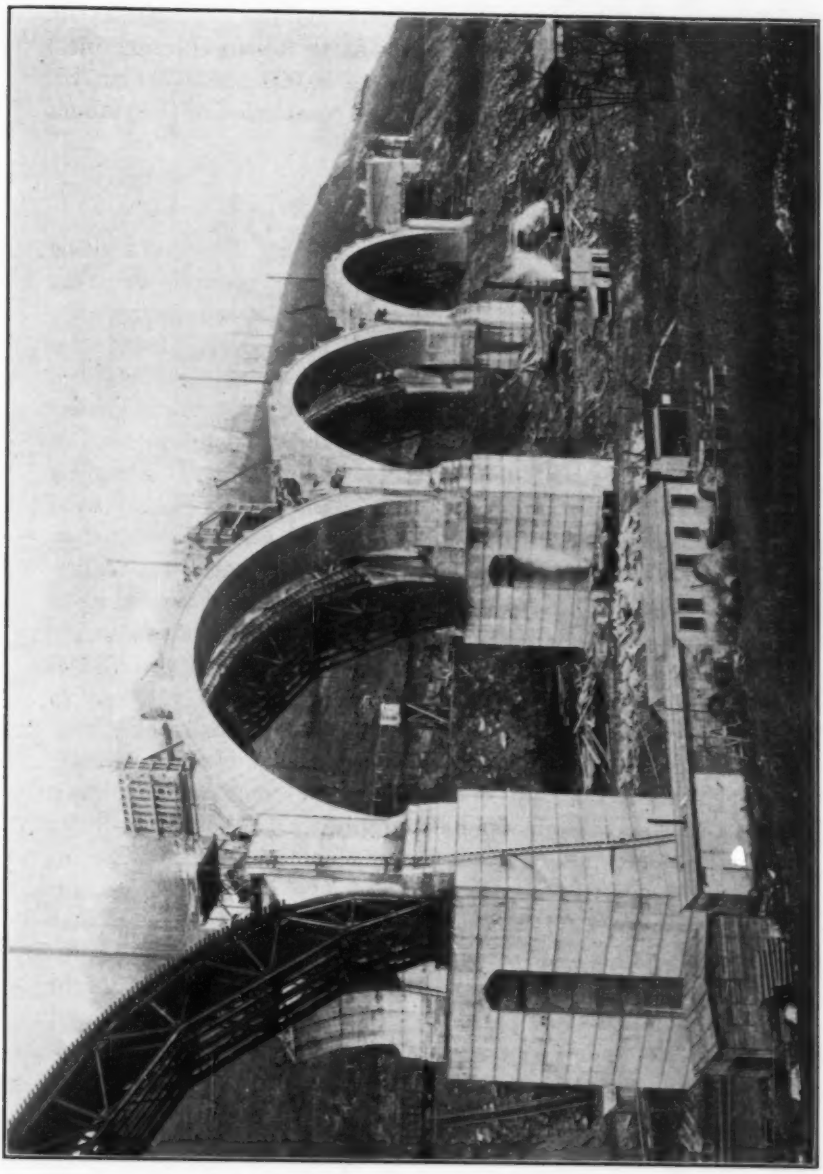


FIG. 14.—MARTIN'S CREEK VIADUCT, KINGSLEY, PA.

with large size derrick stone bedded in the concrete and is used in all the work; below the springing line of main arches 2,300,000 lb. of reinforcing steel will be used. The earth (to the sheeting lines) and the rock excavation will amount to 40,000 and 3,500 cu. yd. respectively. The contract calls for the completion of the viaduct in 3 years. It was begun August, 1911.

MARTIN'S CREEK VIADUCT.

The bridge over Martin's Creek is 1,500 ft. long and is being built for three tracks. The top of parapet of the new structure is 150 ft. above the bed of the stream and 88 ft. above the present main tracks which are bridged by the viaduct. It is composed of two 50-ft. and two 100-ft. semi-circular arches, and seven 150 x 59 ft. three-center arches. The structure is similar in general design to the Tunkhannock viaduct and the method of construction by derricks (shown in part view Fig. 14) is similar to that used for Paulins Kill viaduct. The main piers are solid for 17 ft. below the springing line and below that elevation they are divided into two legs 23 x 28 ft. separated by a 12-ft. opening. All piers are built on solid rock, which is reached at an elevation varying from 10 to 60 ft. below the ground surface, requiring 27,000 cu. yd. of excavation. The viaduct will contain 78,000 cu. yd. of concrete and 500 tons of reinforcing steel.

This viaduct is second in size to the Tunkhannock Creek viaduct, but, like the Delaware River and Paulins Kill viaducts, it is somewhat dwarfed by comparison. This comparison is shown in Fig. 15 where the four viaducts are drawn to same scale.

With the completion of the cut-off line, the Delaware, Lackawanna and Western Railroad will have placed 2,000,000 cu. yd. of concrete since 1900, having placed only 26,000 cu. yd. that year and 50,000 cu. yd. the following year. The average yearly placement is 130,000 cu. yd. and the maximum 226,000 cu. yd. in 1913. About two-fifths has been placed by company forces and the remainder under contract. The company has been very fortunate in its selection of contractors who have taken an unusual pride in obtaining the very best results. This, together with the selection and placing of material under rigid specifications and inspection, has given a quality to the work that impresses even the casual observer with its apparent permanence.

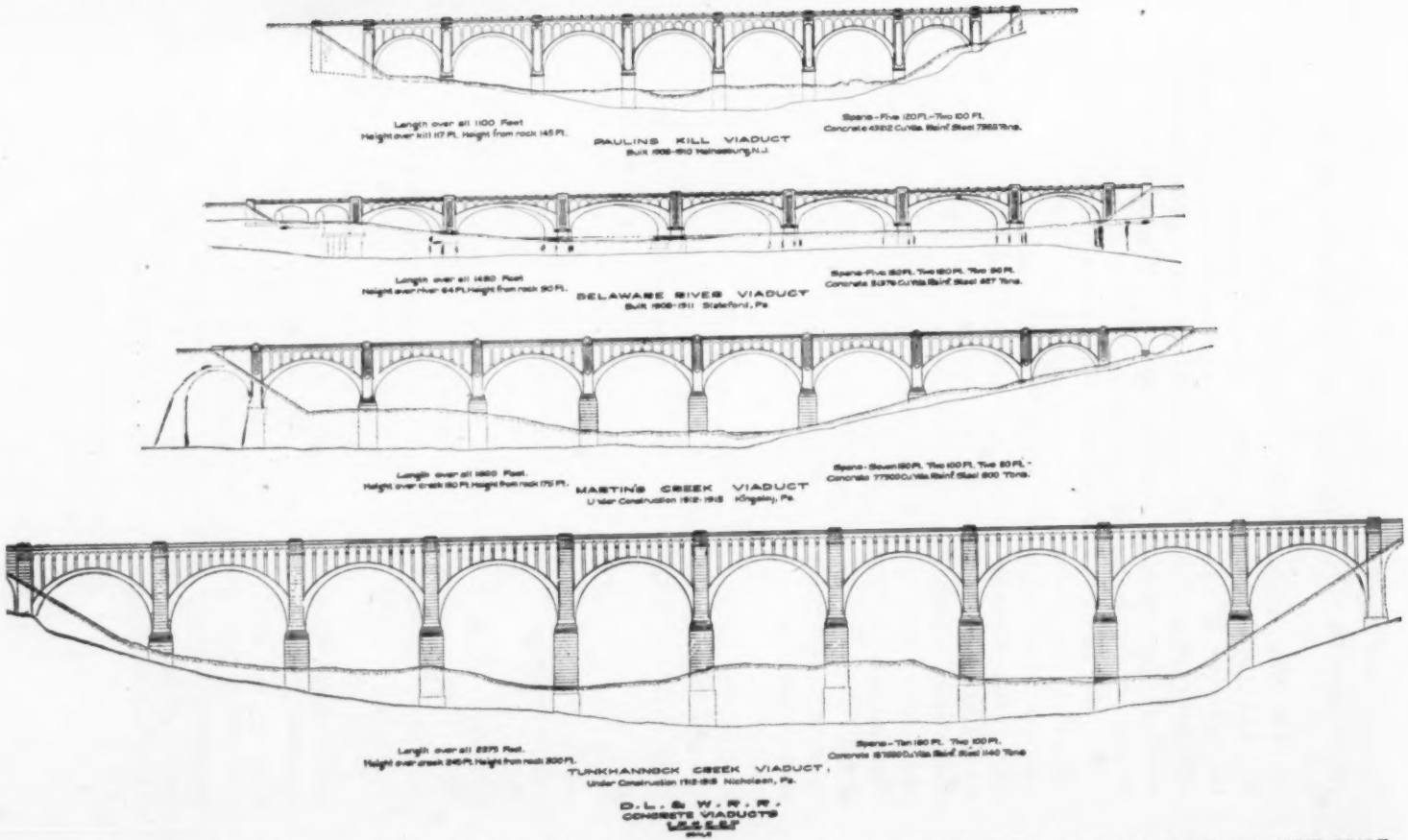

Length over all 1100 Feet
Height over kill 117 Ft. Height from rock 145 Ft.
PAULINS KILL VIADUCT
Built 1908-910 Hohokus, N.J.
Spans - Five 120 Ft. - Two 100 Ft.
Concrete 43512 Cu Yds. Reinf. Steel 7365 Tons.
Length over all 1450 Feet
Height over river 64 Ft. Height from rock 90 Ft.
DELAWARE RIVER VIADUCT
Built 1908-1911 Stafford, Pa.
Spans - Five 150 Ft. Two 120 Ft. Two 90 Ft.
Concrete 51376 Cu Yds. Reinf. Steel 427 Tons.
Length over all 1900 Feet.
Height over creek 150 Ft. Height from rock 175 Ft.
MARTIN'S CREEK VIADUCT
Under Construction 1912-1915 Kingsley, Pa.
Spans - Seven 150 Ft. Two 100 Ft. Two 80 Ft.
Concrete 77900 Cu Yds. Reinf. Steel 800 Tons.
Length over all 2375 Feet.
Height over creek 240 Ft. Height from rock 300 Ft.
TUNKHANNOCK CREEK VIADUCT.
Under Construction 1912-1915 Nicholson, Pa.
Spans - Ten 180 Ft. Two 100 Ft.
Concrete 161000 Cu Yds. Reinf. Steel 1140 Tons
D. L. & W. R. R.
CONCRETE VIADUCTS
LACKAWANNA

FIG. 15.—COMPARISON OF PAULINS KILL, DELAWARE RIVER, MARTIN'S CREEK AND TUNKHANNOCK CREEK VIADUCTS; DRAWN TO SAME SCALE.

The New Jersey Cut-Off was started under the direction of Mr. Lincoln Bush, chief engineer (resigned), and completed by his successor, Mr. G. J. Ray, under whose direction the design and supervision of construction of all the subsequent improvements was performed by company engineers. The stations were designed under the direction of Mr. F. J. Nies, company architect. Mr. B. H. Davis, assistant engineer, whom the writer succeeded, was in charge of the design of the Paulins Kill and Delaware River viaducts. Mr. F. L. Wheaton was engineer of construction on both cut-off lines and was assisted by Messrs. C. W. Simpson and W. L. Lozier, resident engineers during the construction of the Tunkhannock and Martin's Creek viaducts respectively. The construction of the Montclair improvements, also design of coal-handling plants, was supervised by Mr. G. T. Hand, division engineer, assisted in the former by Mr. W. H. Spiers, resident engineer, and in the latter by Mr. C. Healy, assistant engineer.

PROGRESS REPORT ON TESTS OF CONCRETE IN SEA WATER AT THE NAVY YARD, CHARLESTOWN, MASS.

By Leonard C. Wason.*

In 1901, a wharf or pier was built in the Charlestown Navy Yard at Boston in such a way that some of the concrete very badly disintegrated in the sea water after a few years. This started a controversy as to the cause. Some engineers claimed that the cause of disintegration was mechanical, some that it was chemical, while others thought that there were both kinds of action. This series of test specimens was made to find answers to the above questions.

The selection of the material and the method of working it was determined after a discussion carried on in the *Engineering News*, and after receiving the advice of those most experienced in masonry work on the sea front.

Permission was obtained from the United States Navy Department for making and storing some 16-ft. concrete specimens in the Navy Yard at Charlestown, Mass. The specimens were made in January, 1909.

Mr. Herbert L. Sherman, of Boston, a cement chemist of established reputation, co-operated with my company so far as the chemical analyses and quantitative tests were concerned.

The first five pictures (Figs. 1–5) in this report show the method of suspending the specimens under the cap log of the wharf and the method of casting them. The length of the specimens is such that the bottom is always below low water, and the top is above high water.

The first three specimens were made of 1 part cement, 1 of sand, and 2 of stone, and mixed dry, plastic, and very wet respectively. The next three were made of approximately 1 part cement, 2 of sand, and 4 of stone, but so proportioned from a

* President, Aberthaw Construction Company, Boston, Mass.

mechanical analysis of the materials that the excess of cement over the voids of the sand should be 10 per cent and the excess of the mortar over the voids of stone should be 10 per cent. These three were mixed dry, plastic and very wet respectively.

Ten samples were made in pairs, one of each pair being mixed 1:1:2 and the other 1:3:6. All of these were mixed wet. Two were made from a Portland cement practically free from iron; two of a commercial Portland cement high in alumina;

FIG. 1.—THIS VIEW SHOWS NINE OF THE SPECIMENS AT ALMOST LOW TIDE. THE ORIGINAL METHOD OF SUPPORT, BY MEANS OF THE LOOPS IN THE REINFORCING RODS, WILL BE NOTED. AS THESE WERE GRADUALLY WEAKENED BY RUST, RINGS WERE GROUTED INTO THE CORED HOLES IN 1912, AS SHOWN IN FIGS. 6 AND 7.

two of a commercial cement low in alumina; two of an iron ore cement practically free from alumina; and two of slag cement.

The other 5 samples were made of 1 part cement, 3 of sand and 6 of stone, and were mixed quite wet. Number 20 was most thoroughly mixed—much better than ordinary mixing. Number 21 was lost in handling in 1912. Number 22 had 0.1 part by weight of hydrated lime substituted for an equivalent

amount of the cement, thus making the mixture really 0.1 hydrated lime; 0.9 standard Portland cement; 3 parts sand; 6 parts stone. Number 23 was mixed with a Sylvester solution of soap and alum; number 24 contained finely pulverized clay to the amount of 5 per cent of the weight of the cement.

These specimens were all 16 in. square and 16 ft. long. They were reinforced by a bar running through the whole length near two corners, making a loop at the top for the purpose of stiffening

FIG. 2.—GENERAL VIEW OF THE OPERATIONS OF PREPARING THE SPECIMENS, SHOWING IN FOREGROUND THE METHOD OF WEIGHING WATER AND OF MEASURING SAND.

them, for handling and for suspension. The loop proved insufficient for suspension and was later replaced by a big hook grouted into one end in which a hole had previously been cored. These 16-ft. specimens were so hung underneath one of the piers at the Navy Yard, that 4 ft. of the lower end was permanently wet, 1 ft. of the upper end was permanently dry, while over intervening 11 ft. the tide rose and fell. They were put in the water in March, 1909. In December, 1909, the holes above referred to

were sounded for water. All were dry excepting seven, which contained water as follows:

Specimen number.....	1	2	4	5	7	8	15
Inches of water.....	38	65	60	52	19	22	27

Examinations have been made of these specimens from time to time and some photographs have been taken of the speci-

FIG. 3.—SHOWING REINFORCEMENT, AND METHOD OF SUPPORTING PIPE FOR CORED HOLE. THE TWISTED SQUARE, RUNNING THE FULL LENGTH OF SPECIMEN IN TWO OPPOSITE CORNERS, WAS USED FOR SOME TIME AS A MEANS OF SUPPORT FOR THE SPECIMEN. SEE FIG. 1.

mens in about as much detail as that shown in Fig. 1. Such photographs are on file in the writer's office. Reports on the condition of the specimens appear in the *Engineering Record*, August 19, 1911, and in the *Engineering News*, November 20, 1913.

In December, 1913, each specimen was lifted onto the wharf and carefully photographed. Figures 6 and 7 are half-tones of these photographs, made without any retouching. Any one who cares personally to examine these specimens will find them located under the cap log of Wharf No. 9 (see Fig. 1) at the northerly end of the Charlestown Navy Yard. A report of this

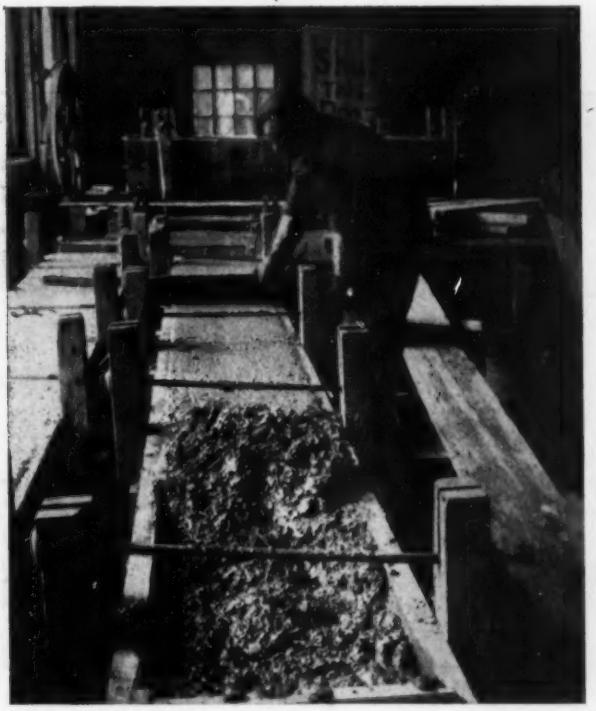


FIG. 4.—LEVELING OFF THE FACE OF A SPECIMEN AFTER POURING.

examination, with illustrations, can be found in the *Engineering Record* of March 21, 1914.

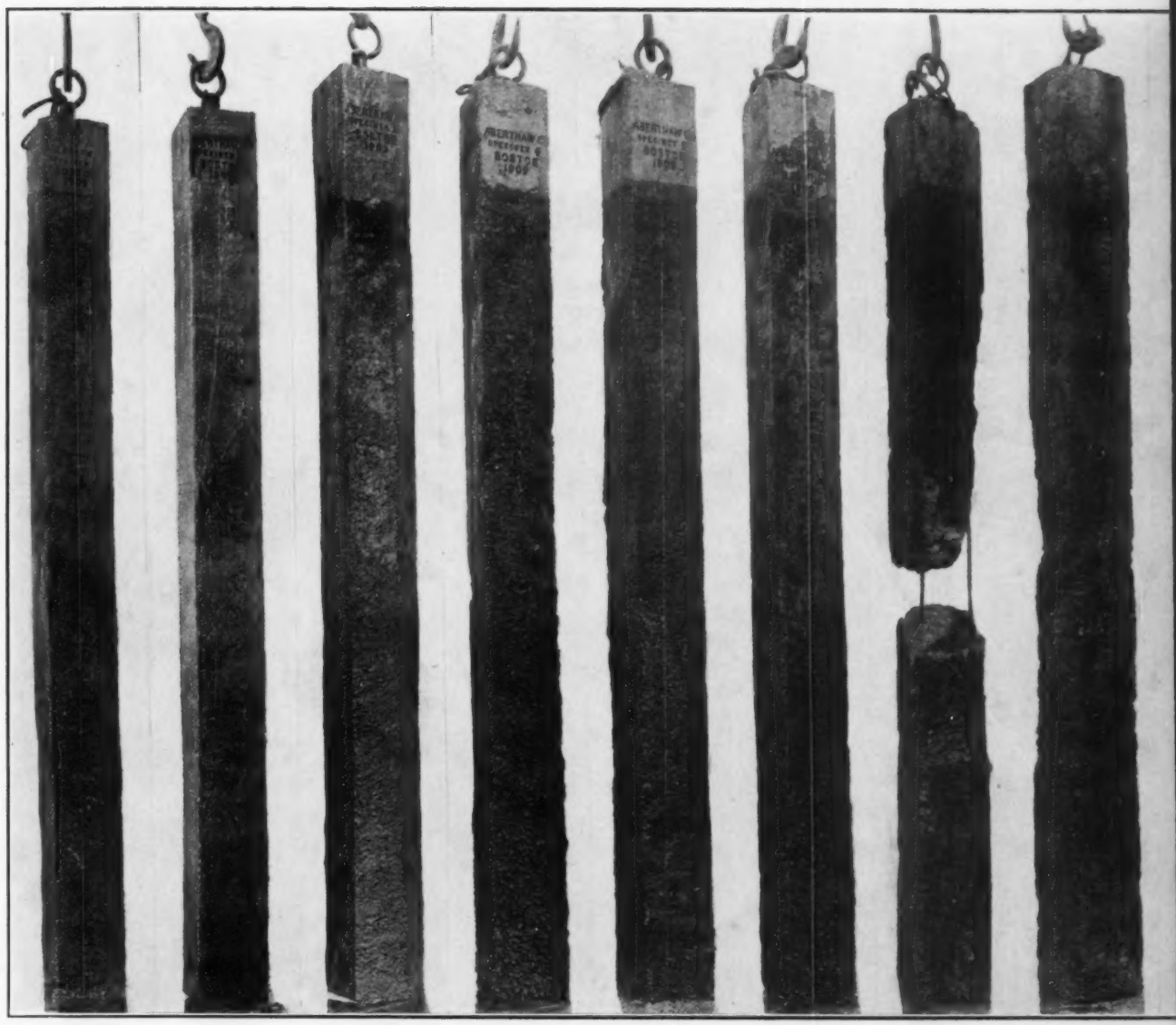
It is too early to draw any definite conclusions as to whether all these specimens will satisfactorily resist sea water or not. Only slight indications of weathering show on some (Fig. 8), while others which were made with the expectation that they

would not long withstand the action of the weather already show signs of failure after 5 years of immersion (Fig. 9). It seems desirable, however, to call particular attention to the fact that specimens Nos. 2, 3, 6, 12, 14, 16 and 18 show little or no effect from the actual elements thus far. One of the specimens, No. 7, made of the proportions 1 : 3 : 6, dry mixture, is now broken in two in the middle and about 1 ft. of its length is missing.

In thinking of these tests, one must remember that the sea water rises nearly to the top of each pier once in 12 hr., and that

FIG. 5.—TO ECONOMIZE IN SPACE, THE FORMS FOR THE LATER SPECIMENS WERE PLACED ON TOP OF SOME OF THE EARLIER SPECIMENS. THE SPECIMENS IN FOREGROUND SHOW BOTH THE LOOP OF THE REINFORCING BAR, BY WHICH THEY WERE LONG SUPPORTED, AND THE END OF THE PIPE MAKING THE SOUNDING HOLE.

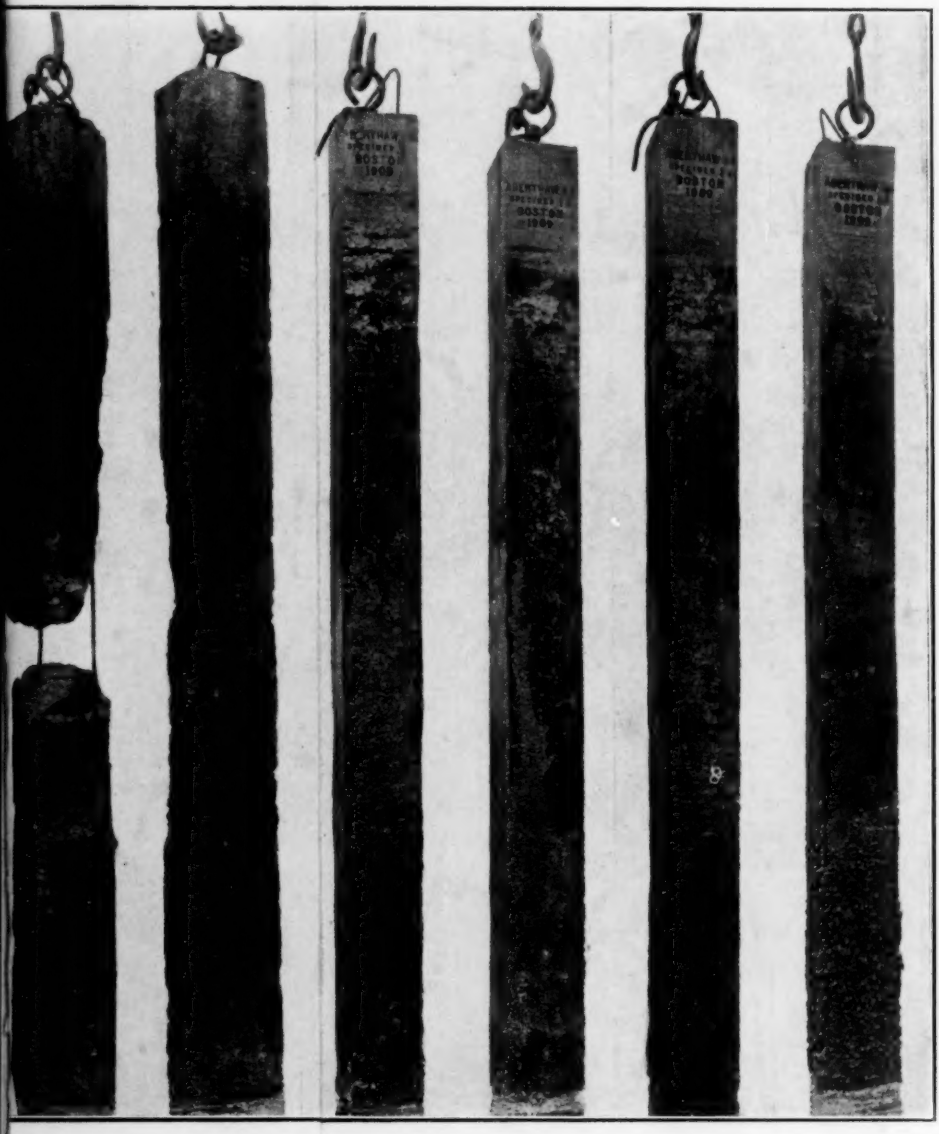
once in 12 hr. the water drops. In cold weather the specimens are thus alternately frozen and thawed. Some of these specimens are mixed so lean in cement that they are necessarily somewhat porous, and it must be considered that any porous masonry subjected to this sort of treatment would show spalling. No final conclusions can as yet be based upon these tests. Only



No. 1 No. 2 No. 3 No. 4 No. 5 No. 6 No. 7 No. 8

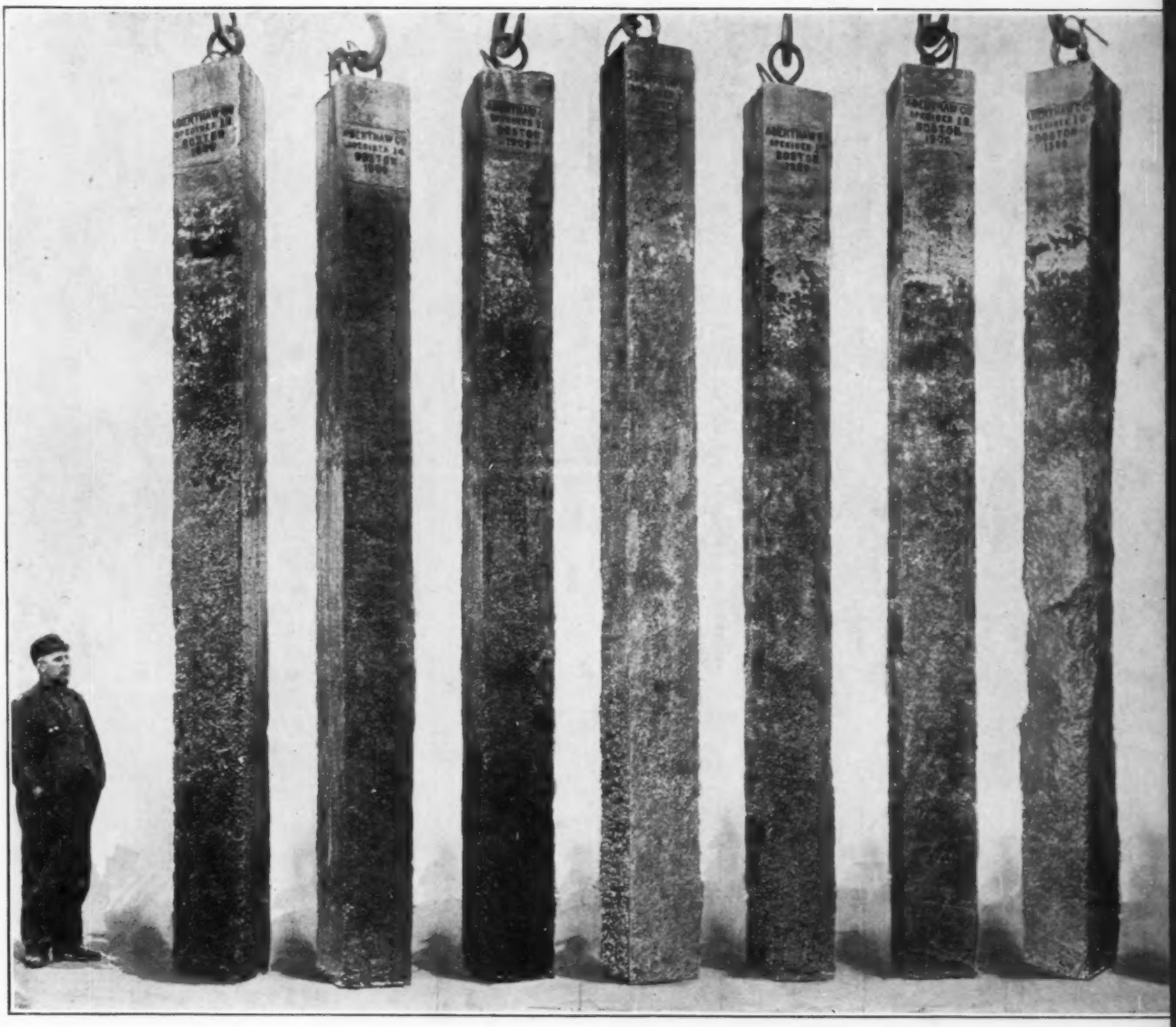
FIG. 6.—SPECIMENS NOS. 1 TO 12 INCLUSIVE. EACH VIEW IS FROM A SEPARATELY TAKEN PHOTOGRAPH (NOT RETOUCHED

PLATE I.
PROCEEDINGS
AMERICAN CONCRETE INSTITUTE
VOL. X., 1914.
WASON ON TESTS OF CONCRETE
IN SEA WATER.



No. 7 No. 8 No. 9 No. 10 No. 11 No. 12

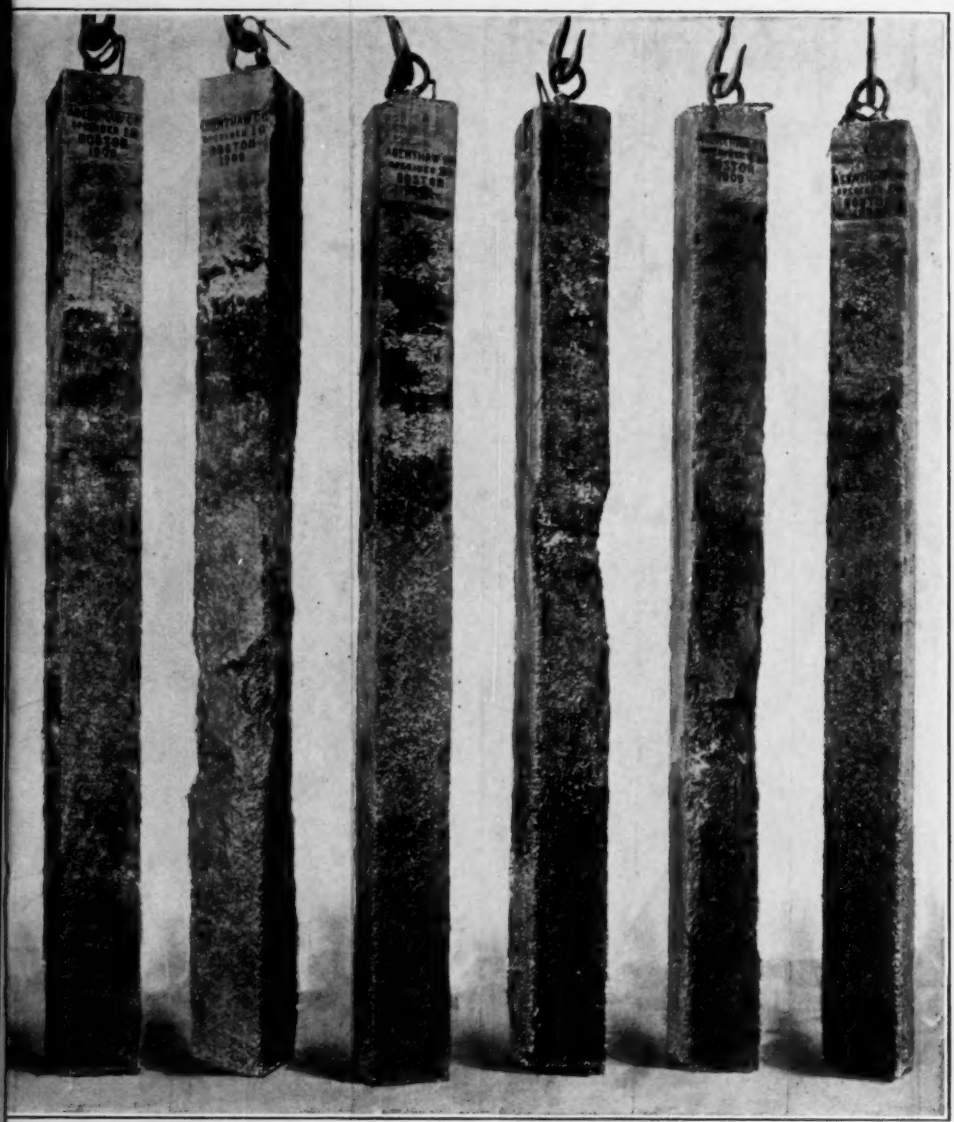
PHOTOGRAPH (NOT RETOUCHED) OF EACH SPECIMEN AS IT APPEARED DECEMBER, 1913.



No. 13 No. 14 No. 15 No. 16 No. 17 No. 18 No. 19

FIGS. 7.—SPECIMENS NOS. 13 TO 20 AND NOS. 22 TO 24 INCLUSIVE. EACH VIEW IS FROM A SEPARATELY TAKEN PHO
APPEARED DECEMBER, 1913.

PLATE II.
PROCEEDINGS
AMERICAN CONCRETE INSTITUTE
VOL. X., 1914.
WASON ON TESTS OF CONCRETE
IN SEA WATER.



No. 18 No. 19 No. 20 No. 22 No. 23 No. 24

FROM A SEPARATELY TAKEN PHOTOGRAPH (NOT RETOUCHED) OF EACH SPECIMEN AS IT
CEMBER, 1913.

FIG. 8.—DETAILED VIEW OF AN "AVERAGE GOOD" SPECIMEN, SHOWING THE AGGREGATE EXPOSED BUT WELL EMBEDDED IN THE CEMENT. THIS SURFACE, WHILE SOMEWHAT ROUGH, IS NEARLY THE ORIGINAL SURFACE.

FIG. 9.—DETAILED VIEW OF AN "AVERAGE POOR" SPECIMEN (NO. 4). THE WHITE IN THE LOWER RIGHT CORNER SHOWS WHERE THE SURFACE WAS PICKED OFF WITH THE FINGER NAIL—INDICATING COMPLETE LOCAL DISINTEGRATION.

(Small barnacles appear on both these specimens—particularly on the left.)

TABLE 1.—GIVING INFORMATION CONCERNING COMPOSITION, TREATMENT AND CONDITION OF SPECIMENS NOS. 1 TO 6.

	Specimen Number.	1	2	3	4	5	6
Proportions.	Cement (Parts.)	1	1	1	1.0	1.0	1.0
	Sand (Parts.)	1	1	1	2.5	2.5	2.5
	Stone (Parts.)	2	2	2	4.5	4.5	4.5
	Water, lb.	248	295	425	165	195	345
Dimensions and Volume.	Average area, sq. ft.	1.690	1.788	1.770	1.790	1.750	1.790
	Length, ft.	16.083	16.000	16.040	16.000	15.917	15.946
	Volume, cu. ft.	27.040	28.610	28.390	28.640	27.850	28.600
	Net volume of concrete, cu. ft.	26.676	28.252	28.044	28.267	27.460	28.225
Weight (in lb.)	Gross	4,110.00	4,320.00	4,250.00	4,175.00	4,180.00	4,350.00
	Net of concrete	4,057.50	4,267.50	4,197.50	4,122.50	4,127.50	4,297.50
	Per cu. ft. of concrete	152.10	151.06	145.04	145.82	150.30	152.20
Treatment.	Cast	January 9, 1909	January 8, 1909	January 9, 1909	January 9, 1909	January 9, 1909	January 9, 1909
	Forms removed	January 11, 1909	January 11, 1909	January 11, 1909	January 11, 1909	January 11, 1909	January 11, 1909
	Immersed in sea water	February 27, 1909	March 1, 1909	March 1, 1909	March 1, 1909	February 27, 1909	February 23, 1909
Condition.	When cast	Cast dry. When cast water glistened but did not spatter. Concrete did not quake.	When cast no water spattered from surface by tamping, but a little movement could be seen as far as 12 in. away.	Cast very wet. When cast the concrete was soft enough to run out of an overturned barrow, but it would not flow like syrup.	Cast very dry. When cast there was no free water, but the surface was moist.	Cast plastic. When cast the top surface was quite wet, just barely spattered and quaked a very little at a few inches from tamp.	Cast very wet.
	March 3, 1910	Front face showed some slight surface erosion, extreme at about half-tide.	Apparently in as good condition as when placed.	Apparently in as good condition as placed.	Slightly pitted on the sides—more so on front face, where the fine material had apparently been eroded, exposing the stones but leaving them firmly embedded. The extreme erosion was about 1 in.	Apparently in as good condition as when placed.	The surface appeared to be somewhat soft.
	December 17, 1913	Face eroded badly for full length. Sides and back probably as good as when poured.	Face, sides and back slightly pitted below mid water. Specimen seems in good condition.	Face somewhat pitted. Edges good, sides good, back good, slightly pitted.	Face badly eaten from high water to bottom—a little worse between high and low water. Aggregate exposed on entire face. Back good—slightly flaked at mid water. Sides look as though specimen had been poorly spaded—aggregates exposed in streaks. A detailed view of the face is shown in Fig. 8.	Specimen slightly pitted on all sides from high water to bottom.	All sides in good condition for full length, face a little pitted, corners eaten a trifle around low-tide.

TABLE 2.—GIVING INFORMATION CONCERNING COMPOSITION, TREATMENT AND CONDITION OF SPECIMENS NOS. 7 TO 12.

Specimen Number.		7	8	9	10	11	12
Proportions.	Cement (Parts.)	1	1	1	1*	1*	1†
	Sand (Parts.)	3	3	3	1	3	1
	Stone (Parts.)	6	6	6	2	6	2
	Water, lb.	182	240	343	305	353	325
Dimensions and Volume.	Average area, sq. ft.	1.820	1.820	1.800	1.800	1.860	1.810
	Length, ft.	16.000	15.964	16.104	15.956	16.000	16.000
	Volume, cu. ft.	29.120	29.050	28.990	30.400	29.760	28.960
	Net volume of concrete, cu. ft.	28.740	28.666	28.616	30.032	29.389	28.579
Weight (in lb.)	Gross	4,150.00	4,255.00	4,215.00	4,320.00	4,350.00	4,225.00
	Net of concrete	4,097.50	4,202.50	4,162.50	4,267.50	4,297.50	4,172.50
	Per cu. ft. of concrete	142.50	146.58	145.40	142.10	146.20	145.90
Treatment.	Cast	January 11, 1909	January 11, 1909	January 11, 1909	January 12, 1909	January 12, 1909	January 12, 1909
	Forms removed	January 13, 1909	January 13, 1909	January 13, 1909	January 14, 1909	January 14, 1909	January 14, 1909
	Immersed in sea water	February 27, 1909	February 23, 1909	February 23, 1909	February 27, 1909	February 27, 1909	February 27, 1909
Condition.	When cast	Cast quite dry, did not quake.	Cast plastic, moderate tamping showed quaking; spots of water on surface.	Cast wet, concrete spattered and quaked. Water ran off.	Cast wet, concrete quaked when tamped lightly. Cement acted quickly.	Cast wet, concrete flowed off shovel easily and when tamped water flowed off form.	Cast wet, quaked with light tamping.
	March 3, 1910	Slightly pitted on the sides—greatest on front side, where the fine material had apparently been eroded, exposing the stones but leaving them firmly embedded.	Apparently in as good condition as when placed.	Apparently in as good condition as when placed.	Apparently in as good condition as when placed.	Apparently in as good condition as when placed.	A very slight action was noticed on the front face.
	December 17, 1913	Specimen entirely eaten through at 3½ ft. above low water, for a foot all gone. Bars holding together. Back side eaten on a slant for 10 ft. Only slightly eaten below low water line. Material dead at eaten section.	Front and sides somewhat pitted. Back face eaten badly from low tide to mid tide for about 2 ft.,—eaten to a depth of 5 in. Streak eaten down center of back side from high tide to bad spot. A detailed view of the back is shown in Fig. 9.	General condition good. Face a little pitted. Edges all eaten a little.	Condition good Bottom and sides hardly touched. Front slightly pitted. Edges fairly sharp.	Condition good. Face pitted slightly from mid water. Back good. Sides slightly pitted around low tide mark. Edges fairly good.	Condition very good. Edges all sharp at mid water. A slight flaking in back. Front slightly pitted from mid water to bottom; a little more above low water.

* Blanc. † Atlas.

TABLE 3.—GIVING INFORMATION CONCERNING COMPOSITION, TREATMENT AND CONDITION OF SPECIMENS NOS. 13–18.

	Specimen Number.	13	14	15	16	17	18
Proportions.	Cement (Parts.)	1*	1†	1	1‡	1‡	1§
	Sand (Parts.)	3	1	3	1	3	1
	Stone (Parts.)	6	2	6	2	6	2
	Water, lb.	345	330	335	315	293	330
Dimensions and Volume.	Average area, sq. ft.	1.800	1.790	1.810	1.800	1.810	1.800
	Length, ft.	15.917	16.000	15.917	15.917	16.000	16.073
	Volume, cu. ft.	28.700	28.640	28.890	28.700	28.960	28.930
	Net volume of concrete, cu. ft.	28.340	28.274	28.520	28.320	28.589	28.580
Weight (in lb.)	Gross	4,100.00	4,130.00	4,125.00	4,290.00	4,225.00	4,215.00
	Net of concrete	4,047.50	4,077.50	4,072.50	4,237.50	4,172.50	4,162.50
	Per cu. ft. of concrete	142.80	144.20	142.70	149.60	145.90	145.60
Treatment.	Cast	January 12, 1909	January 13, 1909	January 13, 1909	January 15, 1909	January 15, 1909	January 13, 1909
	Forms removed	January 14, 1909	January 15, 1909	January 15, 1909	January 18, 1909	January 18, 1909	January 15, 1909
	Immersed in sea water	February 27, 1909	February 23, 1909	February 27, 1909	February 23, 1909	February 27, 1909	February 27, 1909
Condition.	When cast	Cast wet, flowed off shovel easily; slight tamping showed quaking; spattered when tamped hard. Surface glazed.	Cast wet, quaked with light tamping.	Cast wet, quaked with light tamping.	Cast wet. When leveled off showed oily streaks in water on top.	Cast wet. When leveled off showed oily streaks in water on top.	Cast wet, quaked with light tamping.
	March 3, 1910	A very slight action was noticed on the front face.	Apparently in as good condition as when placed.	A very slight action was noticeable on the front, and the face appeared softer than it should.	Apparently in as good condition as when placed.	Apparently in as good condition as when placed.	Apparently in as good condition as when placed.
	December 17, 1913.	Condition fairly good from top to low water line. One corner at low water eaten in about 1½ in. Sides good, bottom good. Face eaten, a little rough all the way down. Edges eaten off.	Condition very good. Corners all sharp for full length. Face only a little pitted. Sides and back hardly touched.	Condition good entire length. Edges slightly eaten. Face pitted. Sides and back hardly touched.	Good all over and on all sides. Apparently no eating action had taken place.	All four sides slightly eaten from high tide to bottom. Most of action around low tide mark. Corners eaten. All eating action on mortar. Stone seems unaffected. Deepest holes less than ¼ in.	Good on all sides. Back slightly pitted.

* Atlas. † Helderberg and Lehigh. ‡ Iron ore. § Universal.

TABLE 4.—GIVING INFORMATION CONCERNING COMPOSITION, TREATMENT AND CONDITION OF SPECIMENS NOS. 19–24.*

	Specimen Number.	19	20	22	23	24
Proportions.	Cement (Parts.)	1†	1	1‡	1§	1¶
	Sand (Parts.)	3	3	3	3	3
	Stone (Parts.)	6	6	6	6	6
	Water, lb	370.	275	325	298	275
Dimensions and Volume.	Average area, sq. ft	1.800	1.790	1.800	1.820	1.810
	Length, ft	16.000	16.000	16.000	16.125	15.104
	Volume, cu. ft	28.800	28.640	28.800	29.340	27.340
	Net volume of concrete, cu. ft	28.425	28.263	28.427	28.970	26.967
Weight (in lb.)	Gross	4,125.00	4,165.00	4,225.00	4,050.00	4,150.00
	Net of concrete	4,072.50	4,112.50	4,172.50	3,997.50	4,097.50
	Per cu. ft. of concrete	143.30	145.50	146.70	137.90	151.60
Treatment.	Cast	January 13, 1909	January 14, 1909	January 16, 1909	January 16, 1909	January 14, 1909
	Forms removed	January 15, 1909	January 16, 1909	January 18, 1909	January 18, 1909	January 16, 1909
	Immersed in sea water	February 23, 1909	February 23, 1909	February 23, 1909	February 23, 1909	February 23, 1909
Condition.	When cast	Cast wet, quaked with light tamping.	Cast normal, quaked with light tamping.	Cast wet, quaked with light tamping. The lime was mixed thoroughly with the dry cement.	Cast wet, quaked with light tamping. Mixed the alum thoroughly with the dry cement; dissolved the soap in water.	Cast wet, showed quaking and spattered from light tamping.
	March 3, 1910	A slight roughness showed on the front face.	A slight roughness showed on the front face.	This specimen showed little change. It was, however, cracked when first placed. When examined this crack showed water leaking out.	This specimen had a very small crack on its face when placed. When examined it was found to be cracked practically all the way through. The corners were eroded in places, which may have been caused by bumps from a floating obstacle.	The outer face was somewhat soft.
	December 17, 1913	Fair above high water line, all sides. Badly eaten between high and low water. Corners all gone, several inches deep in places. Back eaten all over to a depth of up to 4 in. Steel partly exposed. Concrete soft and crumbly. Fair condition below low water mark.	Very slightly flaked on all four sides between low water and half way to high water. Below water, eaten in a few small spots for $\frac{1}{8}$ in. or so. Corners all slightly eaten.	Front face badly pitted from mid water clear to bottom; not quite so bad on lower 2 ft. At mid water badly eaten to depth of 4 in. Material soft and dead at this point. Sides and back equally pitted. Crack in middle worst eaten part.	Face badly eaten just above low water mark. All four edges and back badly eaten for 3 ft. below low water mark. Corners at bottom gone. All faces slightly pitted. Not much action above mid water line.	Good above water line. Surfaces between high and low tide eaten somewhat. Corners eaten all the way from high water to bottom. Took close photograph of small section showing typical eating. Face little worse than sides.

* Specimen No. 21 was lost in handling in 1912. † Universal. ‡ 0.9 cement, 0.1 hydrated lime. § Sylvester solution-soap and alum used.
¶ 5 per cent (2¾ lb.) pulverized clay.

TABLE 5.—RESULTS OF PHYSICAL TESTS OF CEMENT.

Cement.	Fineness, Percentage Passing Sieve No.		Material Added.		Time of Setting in Minutes.		Tensile Strength in Pounds per Square Inch.									
							Neat Cement.				1 : 3 Ottawa Sand.			1 : 2 Bank Sand.		
	100	200	Per Cent.	Nature.	Initial	Final.	Per Cent Water.	24 Hours.	7 Days.	28 Days.	Per Cent Water.	7 Days.	28 Days.	Per Cent Water.	7 Days.	28 Days.
White Portland	94.4	75.0	..	..	25	200	23	277	549	726	9	191	319	10	159	218
Portland with average alumina	94.8	79.6	..	..	95	285	22	313	660	755	9	264	360	10	217	318
Portland with high alumina	94.2	76.2	..	..	105	250	22	342	677	744	9	272	304	10	168	211
Portland with low alumina	93.8	78.8	..	..	130	322	22	312	636	741	9	184	312	10	133	271
Iron ore	95.8	82.6	..	..	45	1,560	22	000*	441	641	10	132	234	11	108	174
Portland made of slag	95.6	78.8	..	..	35	120	22	315	608	717	9	194	258	10	166	181
0.9 Portland with average alumina and 0.1 hydrated lime	95.2†	88.2†	10	Hydrated lime.	10	240	25	276	566	717	9	148	216	10	117	182
Portland with average alumina and 5 per cent pulverized clay	99.0†	58.0†	5	Clay	100	280	22	248	723	762	9	211	255	10	169	222

* 48 hr. 223 lb. † Fineness of added material.

long years will show whether any of the specimens will prove permanent. Tables 1 to 4 give particulars as to the composition and condition of the specimens shown in Figs. 6 and 7.

Nothing out of the ordinary was noticed in the tests of the cement used in the specimens given in Table 5 except the very long time taken by the iron ore cement in attaining hard set. This is interesting as showing the effect on the set of the almost total absence of alumina. The use of hydrated lime was shown to give a very quick set; although the initial set was very rapid, the paste was easily worked to a soft mix for several hours after getting its initial set.

The results of the chemical analyses of the cement and hydrated lime used in these tests are given below.

TABLE 6.—RESULTS OF CHEMICAL ANALYSES.

	Material.	Loss on Ignition.	Silica (S_iO_2)	Alumina (Al_2O_3)	Iron (Fe_2O_3)	Lime (CaO)	Magnesia (MgO)	Sulphuric Anhydride (So_2)	Carbon Dioxide (Co_2)
Cement.	White Portland	1.69	24.58	0.29	8.22	62.70	1.11	1.32	....
	Average alumina	0.96	22.08	2.57	7.21	62.60	2.74	1.56	....
	High alumina	1.06	21.46	2.44	8.50	61.64	2.58	1.75	....
	Low alumina	1.04	23.40	2.37	5.61	62.90	2.51	1.53	....
	Iron ore	0.91	24.28	9.08*	0.94	62.12	0.43	1.75	....
	Made of slag	2.82	20.42	3.04	8.04	62.16	1.63	1.73	....
Hydrated lime		1.32	18.73*	0.68		45.88	31.62	....	1.51

* Including insoluble matter.

The sand, which was very fine, was clean and of good quality. It contained 34.2 per cent of voids (by volume), 4.6 per cent of moisture (as used), averaged (dry) 98.18 lb. per cu. ft., and gave the following mechanical analysis:

Number of screen	¼ in.	6	8	10	16	20	30	50	100
Percentage passing (by weight)	100	96.1	93.4	91.0	86.4	73.4	52.0	24.0	4.8

The stone was a broken trap, of very good quality, containing 50 per cent of voids (by volume), weighed 90.24 lb. per cu. ft., and gave the following mechanical analysis:

Size of screen (inches)	⅛	3/16	¼	⅜	½	¾	1	1½
Percentage passing (by weight)	0.25	0.50	1.75	9.75	25.25	53.00	80.75	100.00

STEEL FORMS FOR CONCRETE CONSTRUCTION.

By C. D. McArthur. *

There is no single piece of plant equipment used by the contractor which lends itself more readily to the completion of good concrete work than the forms, yet we often find a greater neglect of them than of any other part of the plant. Reviewing projects wherein concrete has been used with the aid of forms, we find a great waste of time and materials, showing that not enough thought was given to the proper designing and handling of this part of the work. In many instances forms are the last things thought of by the contractor. An item covering the subject is to be found in their estimates, but often there is a lack of real knowledge displayed in making up this item.

There are many pieces of concrete construction which do not require special forms; but a piece of work requiring forms that may be moved and reused a number of times, is sufficiently important to warrant economical methods of handling.

It is the duty of the engineer to study economical methods of building for the structure he designs, and by doing this he can greatly reduce the cost. The ability to work his plant to the best advantage enables the contractor to make low costs and do his best work.

In many instances the speaker criticises the engineer for paying more attention to the theory of design than to practicability. The standardization of details and the duplication of parts would greatly reduce the general cost of the structure designed. Many cases can be cited where the cost of forms could have been lowered had the design been made with that end in view. The designing engineer should keep in mind that part of his value to his client is in his ability to design a structure of the most economical type, and it is his duty to point out and design for him a form which can be duplicated so often that it enters into the construction of his work as a most important tool.

* Chief Engineer, Blaw Steel Construction Company, Pittsburgh, Pa.

In a recent work on "Concrete Costs" the author says that, "the greatest trouble met with by the estimator is the lack of knowledge of what is a fair cost of the labor, and especially of the comparative costs of different parts of the same work." He also observes that, "the variations in form costs and the difficulty in estimating them are apt to play havoc with estimates and determine the amount of profit, or frequently of loss, in the building of reinforced concrete structures."

We find few contractors or estimators who can give accurate costs of the forms on much of their past work. It is difficult to convince a contractor that steel forms are the ones to use when the first cost is invariably higher than wood forms, unless he has given a great deal of attention to accurate form costs and knows that the life of wood forms cannot be compared with that of steel forms.

There is no doubt that the form manufacturers are to blame in many cases for the adverse opinion of steel forms. The reason is that they have been over anxious to place steel forms on every concrete job that comes along and have, therefore, placed a great many forms on jobs that did not warrant the use of steel.

House building with an all steel form is today out of the question. Good steel forms have been developed for constructing light walls, such as are found in house construction, but the ability to set up a form and pour the house in one operation is far from being a reality. There is no field of construction where greater individuality may be displayed than in building houses and for that reason a machine-made house is not yet a commercial success. Past performances have not shown that steel forms can be used successfully in the construction of workmen's houses unless the work is carried on in stages with a limited supply of forms.

The steel form has become one of the most important adjuncts to the concrete plant and no contractor can successfully conduct all of his work without giving serious consideration to their use. No single piece of apparatus has made a greater impression on the contractor's work. Many articles relating to tunnel construction, aqueduct building, sewer and concrete costs are being published with only a passing reference or none at all to the steel forms which no doubt played a most important part in their construc-

tion. The publisher's point is that generally the steel forms, being a patented article, should not be advertised too much in the reading matter of his paper. But his paper serves his subscribers best by diffusing as much exact knowledge as possible, and the contractor is grateful for all the data he can get about the work in which he is interested. The steel form industry is here to stay, but the manufacturers should not try to lead the contracting engineer to believe that all concrete work must be constructed with their product.

Consideration must be given to the following points before all branches of the concrete contracting industry will be benefited:

First—Uniformity of concrete design, to which reference has been made.

Second—The development of standard designs of steel forms for various classes of work, such as sidewalks, columns, beams and girders, walls, sewers, etc., which can be leased to the small contractor at a low rental price or sold outright to those whose business warrants their purchase as a part of their plant. The rental method of placing forms at the disposal of the contractor is the most profitable to him as well as to the manufacturer, as it allows the latter good profits on his first cost of production, and enables the contractor to obtain the use of the forms at a much lower figure than as if he purchased them outright.

Third—The contractor should content himself with the forms that can be had from the manufacturer under a guarantee that they will do the work required, as this is more profitable than to impose conditions as to the details of construction which will greatly increase the form cost and be of no real value to the work.

An impression prevails among contractors who have not used steel forms that they should be erected and handled without visible labor, and that they can be moved without thought or energy. Granted that if steel forms could not be more easily handled than wood forms they would not be used in many cases, there are other reasons why steel forms should be used; foremost of which is that steel forms, to be of any value, must cast as good concrete the last time they are used as they did the first. It is almost impossible to get many moves from wood forms before they

begin to give a rough surface to the concrete, or before they require additional work to keep them in shape. Not so with steel forms. A good, well designed steel form can be used several hundred times. The speaker has seen steel forms after 200 moves cast a surface so smooth that it would reflect light. If the inspection of the work permits a rough surface resulting from the use of wood forms on which every grain of the wood shows, there is no use dwelling on the virtue of the smooth surface obtained through the use of steel forms.

The designers of steel forms should keep in mind that it is simplicity, rigidity and economy of handling which make their product valuable. Simplicity implies that the forms must be capable of being moved and handled with the least amount of skilled labor, or any kind of labor. This can only be accomplished by making all parts interchangeable. This applies more to forms that are placed on the market as a standard, such as sewer, house, sidewalk, and forms of like nature. Every form job must be studied on its own merits. It is often impossible to keep away from special parts where forms are designed for a special piece of work. In this case the designer should remember that he must take from rather than add to the number of parts required, thus making the design as simple as possible. Rigidity forgotten has caused many a form to give way under its load and ruin the concrete. It matters not how simple the design is, if the form is too light it is of little or no value. Wall and house forms must be able to take all pressures placed upon them. With the rods spaced at intervals the pressure must be evenly distributed so that no bulging of the plates occurs. This can only be accomplished by causing the tie rod to receive its load from some important member which in turn has received its load from the plate. In case of sewer forms of the arch design, they can be lighter per square foot than any other type, but must not be so light as to distort under load. Sidewalk forms have their value chiefly in their simplicity of erection and the removal of the several parts. Round column forms produce a true round smooth surface, which it is impossible to obtain with wood forms.

Economy of handling steel forms must be placed next to longevity. If the form manufacturer can not show that his steel forms can be handled more cheaply than wood forms he will

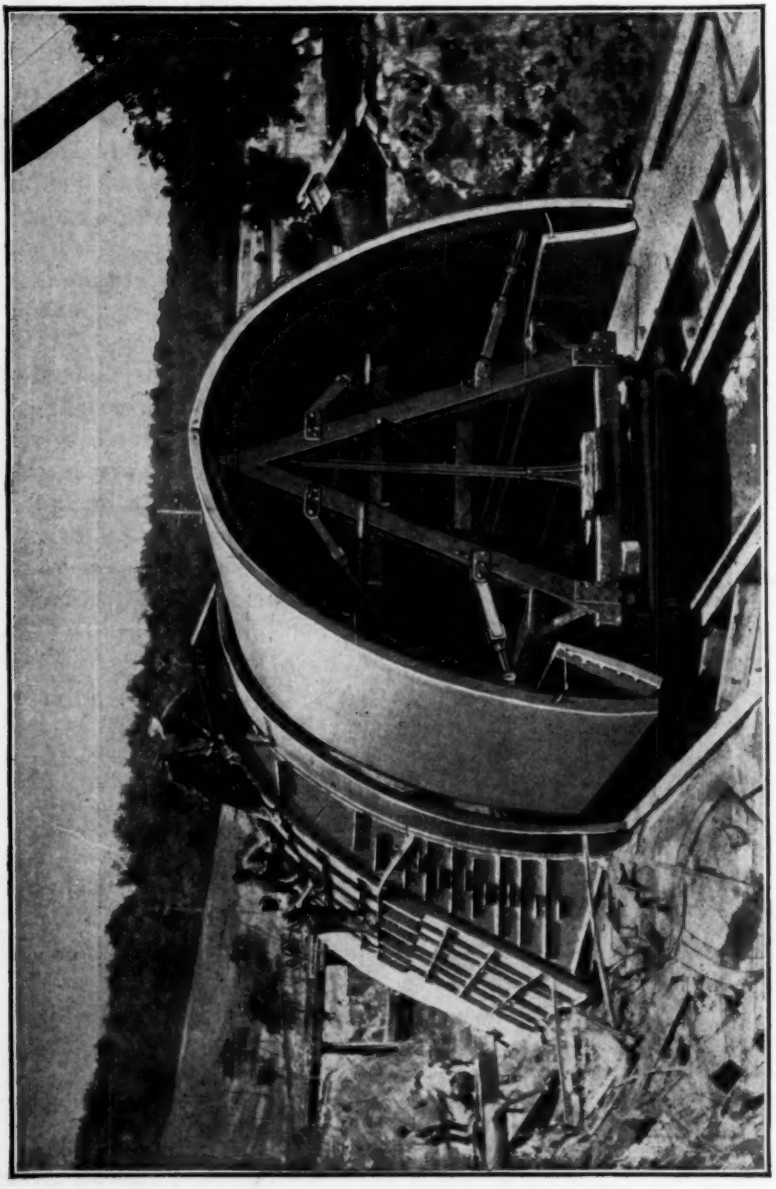


FIG. 1.—THREE-HINGED TELESCOPIC FORM, CUT AND COVER SECTION, CATSKILL ACQUEDUCT.

have a hard time making a sale. Marked ingenuity has been displayed in steel form design in the handling mechanism. It is to the advantage of the contractor to look carefully into the method of handling the forms rather than to details of construction. There are no forms on the market that show no marked weakness in details; but to erect and move them is another story.

Let us dwell no further on the possibilities of using steel forms and the reasons therefore, but hasten to a review of the many engineering projects where steel forms have been used. It can not be claimed in all cases that the use of steel forms has resulted in an economical method of construction, but we surely would not be able to show so many excellent examples if the steel form did not possess great merit. The speaker believes there have been few large engineering projects constructed in this country in the last 5 years on which steel forms were not used in parts or in all the work. Among those of great importance are the locks of the Panama, Erie and Soo canals, the New York subways, the Catskill Aqueduct, and the new sewerage systems of Louisville, Indianapolis, St. Louis, Baltimore and Brooklyn.

Aqueducts.

The Catskill Aqueduct has proven the superiority of steel forms over wood to a greater degree than any other engineering project. The great length of this aqueduct, divided as it is into cut-and-cover, grade and pressure tunnels, with each type uniform in section, made the use of steel forms a necessity. It is in this work that the designing engineers kept in mind the value of standard sections. There was used more than 7,000 tons of steel forms on this work. It would take 250 cars to transport them, and if hauled in 5-ton auto-trucks they would require a train of trucks more than 7 miles long.

With the exception of a few sets of these forms, all that were used on the cut-and-cover work were telescopic (Fig. 1), and were so constructed that they could be used on curves as well as on tangents. This was accomplished by making each section of forms similar to the sections of a stove pipe. When the sections of forms were assembled with all of the short sides of the section

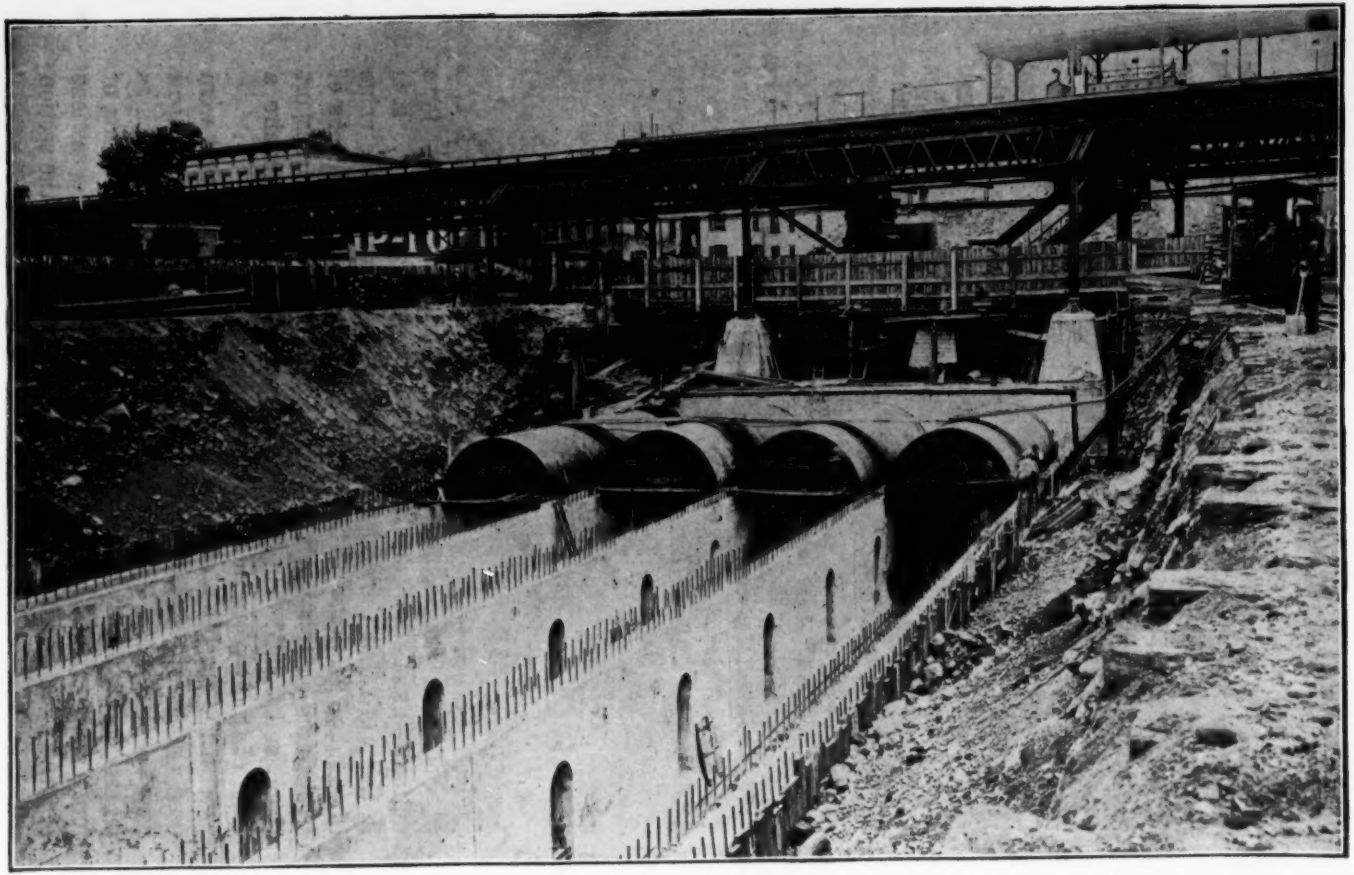


FIG. 2.—SUBWAY FORMS, LONG ISLAND RAILROAD, BROOKLYN, N. Y.

on one side of the work, they would take a curve of 200 ft. radius, and when the sections were assembled with short and long sides of the sections alternating, they would make a straight line. The reversing of the sections was done on a turn table traveler on which the forms were moved. The outside forms were made for tangent and curved sections in a similar manner to the inside form. The outside forms were generally handled by a locomotive crane which ran on a track near the trench. The cost of handling the inside and outside forms in this cut-and-cover work ran around 16 cents per yd., or about 0.8 cent per sq. ft.

The grade tunnels were of the same height (17 ft.) as the cut-and-cover, but were 13 ft. 4 in. wide. Steel forms were used for all of these tunnels aggregating a length of over 12 miles. These forms were constructed with a working deck about 11 ft. above the sub-grade, allowing ample room for placing the concrete from this deck and giving clearances for the passage of work cars under the working platform.

The pressure tunnels, which total more than 40 miles, are being lined with steel forms throughout. Nearly all of these forms are of the half round type. One-half circle works on the side walls and invert and another half circular form is used on the crown. The cost of moving half circle tunnel forms of diameters over 12 ft. is 1 cent per sq. ft. Grade tunnel forms have been moved as low as 0.5 cent per sq ft.

Subways.

The New York subways have presented a more difficult steel form proposition than the Catskill Aqueduct. On account of many of the subways being constructed, of steel columns, beams and girders encased in concrete in the shape of jack arches, in the maize of timbering required to support the streets and adjacent buildings, it is almost impossible to use steel forms to great advantage in any considerable amount. Many sections of this work are being constructed on steel forms of a light rigid type that are giving great satisfaction. The heaviest steel forms used in subway construction were those of a section on the Fourth Avenue Subway in Brooklyn. These were built in four 40-ft. units, placed side by side; the four tubes being constructed in one operation (Fig. 2). These forms weighed over 1,400 lb. per ft.,

and with the aid of screw jacks and chain hoists, so arranged that a 40-ft. section could be collapsed at a time, a section was moved and re-set in less than 2 hours, at a cost of less than 0.5 cent per surface foot of forms. Another interesting set of steel forms is being used in the construction of another four-track subway in Brooklyn. The contractor was so well pleased with the progress he was able to make with these forms that he has duplicated his

FIG. 3.—HALF-ROUND SEWER FORM.
(Constructing Brick Crown.)

order. In the construction of the new Boston subways, large numbers of steel forms also are being used.

Locks.

The lock now being constructed at the Soo is one of the largest in the world. The side wall with an unbroken length of over 1,300 ft. has given an excellent opportunity to use steel forms to the best advantage. The forms are erected in 30-ft. units 50 ft. high, and six such units weighed 450 tons, or 100 lb. per sq. ft. One thousand yards of concrete was deposited continuously in one wall block. The deflection of the plates was never more than $\frac{1}{3}$ in.

Sewer Forms.

Some opposition is still encountered to the use of steel forms for sewer construction. If the sewer is long enough, regardless of its shape, there is no doubt that steel forms are better than those of wood.

As a matter of fact the first steel forms placed on the market were for sewers for which use they have been a great success from the start. There have been hundreds of miles of sewers built over steel forms in cities all over the country (Fig. 3). Circular and egg-shaped sewer forms can be rented at such a low price that no contractor can afford to use wood.

FIG. 4.—HALF-ROUND SEWER FORM. (Constructing Invert.)

Many excellent pieces of work could be referred to but special attention is called to the 25-ft. semi-circular sewer in St. Louis, which is one of the largest in this country. The Passaic Valley Sewer, designed to carry sewage from cities along the Passaic River to New York Bay, is being built on steel forms for almost its entire length. At New Orleans a 25-ft. flat top box sewer is now being constructed on steel forms. It matters not whether the sewer is round, egg-shaped, box or horseshoe shaped, the speaker strongly advocates the use of steel forms. Many city engineers throughout the country are favoring the use of steel forms and are calling for them in their specifications.

The accepted method of using forms for sewer construction where the work is carried on in two stages (first the invert and second the crown), is to use only half the number of forms on the invert that is used on the crown, as it does not injure the

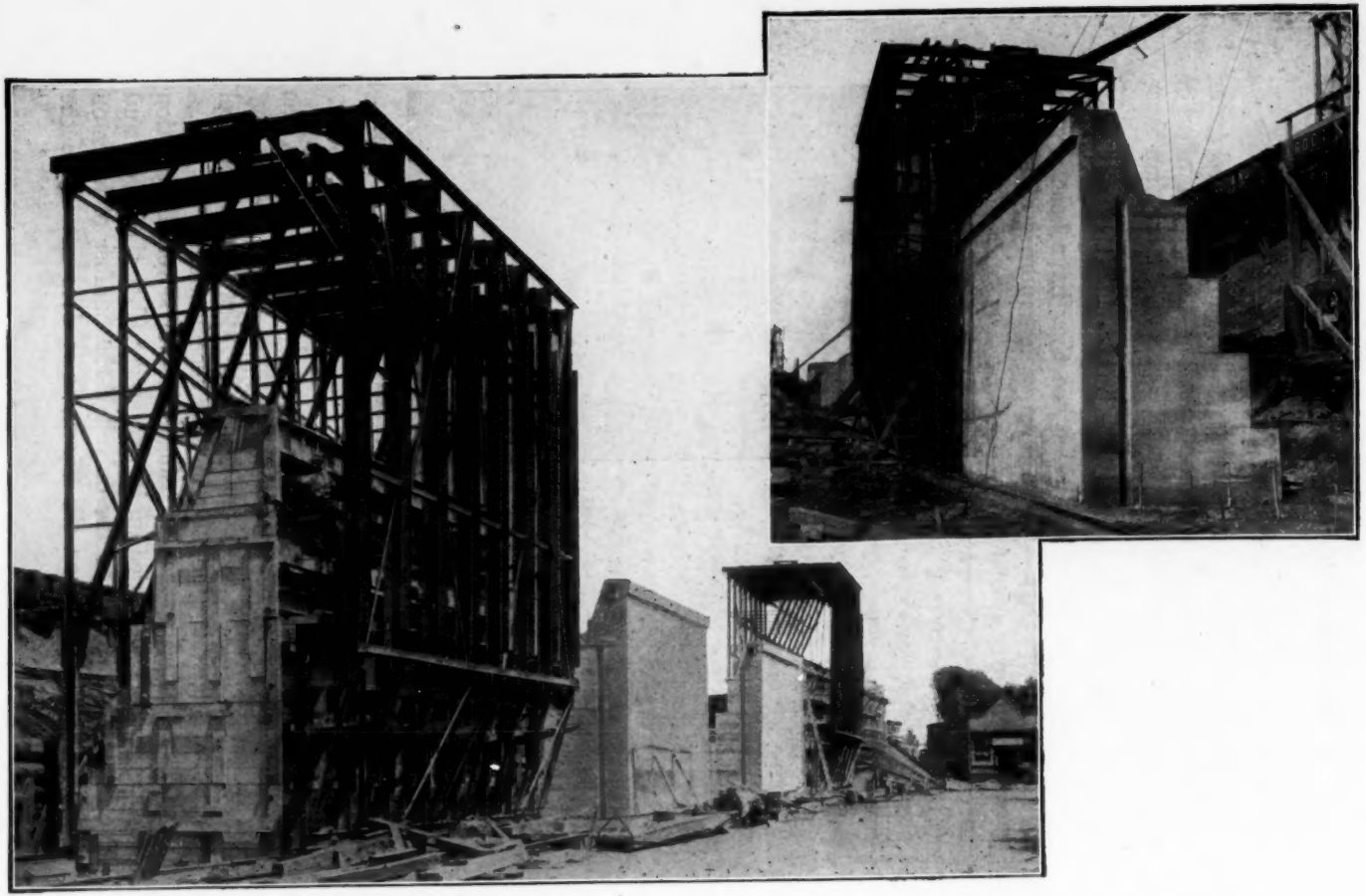


FIG. 5.—TRAVELING WALL FORMS, CHICAGO, ROCK ISLAND AND PACIFIC RAILWAY TRACK ELEVATION WORK, CHICAGO, ILL.

invert to move the forms a few hours after the concrete is set. Curves (Fig. 4) can easily be taken care of by opening the joint of the sections and using a thin cover plate at the joint. Twelve 5-ft. sections of crown forms have been pulled ahead at one time at a cost of from 10 to 15 cents per ft.

Wall Forms.

Retaining walls are excellent concrete jobs on which to use wall forms of a type heavier than house forms. On work of this kind the best results have been obtained by the use of special travelers with which the forms are moved (Fig. 5). Concrete in large mass can be placed in these forms with little danger of buckling the plates. This kind of wall form can be leased from the manufacturer at a low rental price, or can be purchased outright by a contractor who desires to add them to his plant equipment. Forms of this type can be moved with a traveler for $\frac{3}{4}$ cents per sq. ft. The forms used at Panama, as well as the forms used at the Soo, were of a special type. Special forms of heavy type were used on the Erie Canal. These forms are made from heavier plates than standard forms. They are also reinforced with angles and channels, and are carried by the traveler, which is heavy enough to hold the forms against the concrete pressures.

House Forms.

House and light building forms are fast gaining favor with contractors who do such work as light wall, house and foundation work. There is a form consisting only of plates which are held together by a hand locking device attached to the plate; this is the simplest on the market, as there are but few pieces to handle. Another form of similar type is lined up and kept in adjustment with metal liners which are attached with clips and wedges. This is more easily kept in alignment than any of the house forms. Forms of this type are moved and re-set at a cost of 1.5 to 3 cents per ft.; depending entirely on their size. No special traveler or moving crane is required to handle them as all parts are light and can be easily moved by hand. The same house form can be used on walls of considerable height by removing the lower courses and raising them to a higher position. On account of the great

variation of design in work of this kind, no standard form has yet been designed for it.

Column Forms.

Column forms of the square and circular type can be leased at a very reasonable price. Contractors of building construction should investigate the column forms and cap forms that are on the market, as there is a great economy in their use.

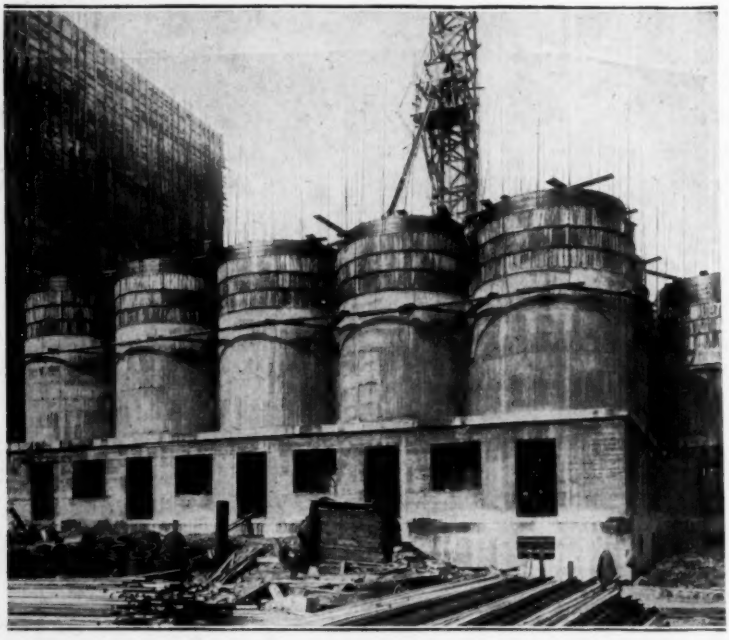


FIG. 6.—GRAIN SILO FORMS, COMMERCIAL MILLING COMPANY, DETROIT, MICH.

Sidewalk Forms.

Sidewalk, curb and gutter forms can be purchased at a very low price and no contractor today can afford to use wood forms for this work.

Silo Forms.

Silo forms are also on the market as a standard article. Little can be said of their economy unless an outfit is used in the construction of many silos (Fig. 6).

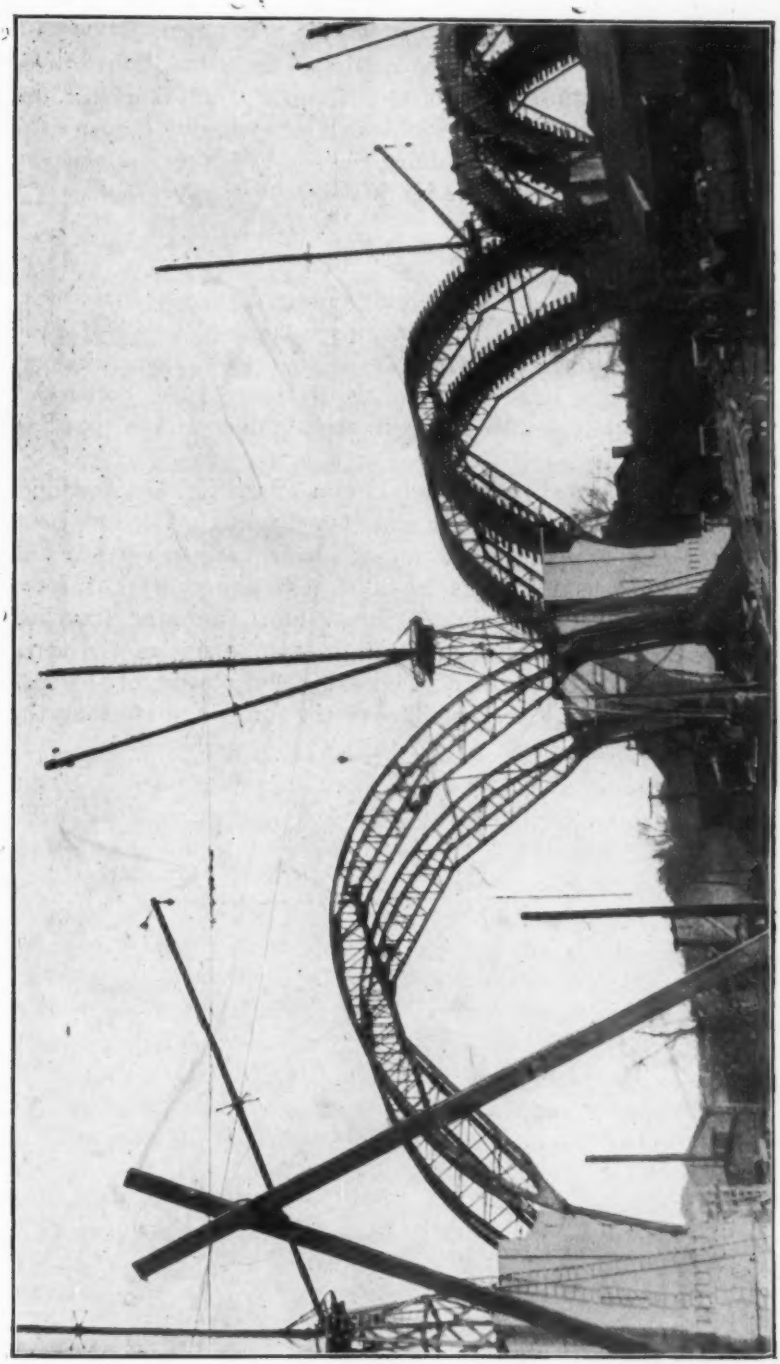


FIG. 7.—ARCH RIBS, 120-FT. SPAN, EIGHTH STREET VIADUCT, ALLENTOWN, PA.

Tunnel Forms.

Sand Patch Tunnel on the Baltimore and Ohio Railroad was lined with four 40-ft. units of steel forms. The tunnel is 31 ft. wide and over 4,000 ft. long, and with these 4 units of forms the contractor broke all tunnel lining records by a progress of 40 ft. of finished tunnel every day for 50 consecutive days.

Steel Ribs.

Steel ribs for arch and bridge construction are now being extensively used. Steel ribs have been used on the 120-ft. span bridge at Allentown, Pa. (Fig. 7), on the 115-ft. span bridge at Baltimore, on the large bridges of the Delaware, Lackawanna and Western Railway, and on many other bridges in the past few years.

We find a great many special forms on the Catskill Aqueduct aside from the cut-and-cover and tunnel forms. Here we have block forms for casting the facing blocks used in constructing Kensico Dam. The blocks are about 3 ft. square by 7 ft. long. The concrete is placed in the forms direct from the traveling mixing plant which runs on tracks on the outside of the three rows of forms. The cost of the mixing and placing of the concrete, together with the handling of the forms and stacking the finished blocks, is about $1 per yard.

DISCUSSION.

Mr. Leonard C. Wason.—I would like to say a few words in regard to steel wall forms of the type described by Mr. McArthur. The company in which I am interested has used them on two different buildings. It is quite interesting to note that the attitude of the contractor's field force has a great deal to do with success in the use of the forms; although those in the main office may feel very favorable to their use. Mr. Wason.

On one job the superintendent, though he liked the forms, was not especially enthusiastic for them. He was using a small quantity on one part of his building, and in three other parts he was exactly duplicating the operation with wooden forms. As there was not a great deal of it, the work was intermittent. He sometimes used a new gang of men each time the steel forms were moved. In this case, the direct wage cost to make, erect and strip was 12.8 cents per sq. ft. and the wood work cost 10.8 cents per sq. ft. of surface content.

On another job, the traveling superintendent and job superintendent were both enthusiastic over the use of steel forms and spent considerable time and thought on their use. Much better results were thereby obtained. Here, by the way, they were used exclusively, so that the men were broken in to use them constantly. The first time was in an experimental way in a temporary shanty that was put up for the men's use during extremely cold weather. Fig. 1 shows the second building considered under construction, with the steel forms in place. The sample cost 7.5 cents set up. The first time they were set up on the job they cost 10.5 cents, including the original assembling. The most straightforward part of this work was arranged as task and bonus work. There were three carpenters at 55 cents an hour and three helpers at 30 cents in each gang. They erected the work for 5 cents per sq. ft. This shows how the attitude of the job superintendent is reflected in the costs.

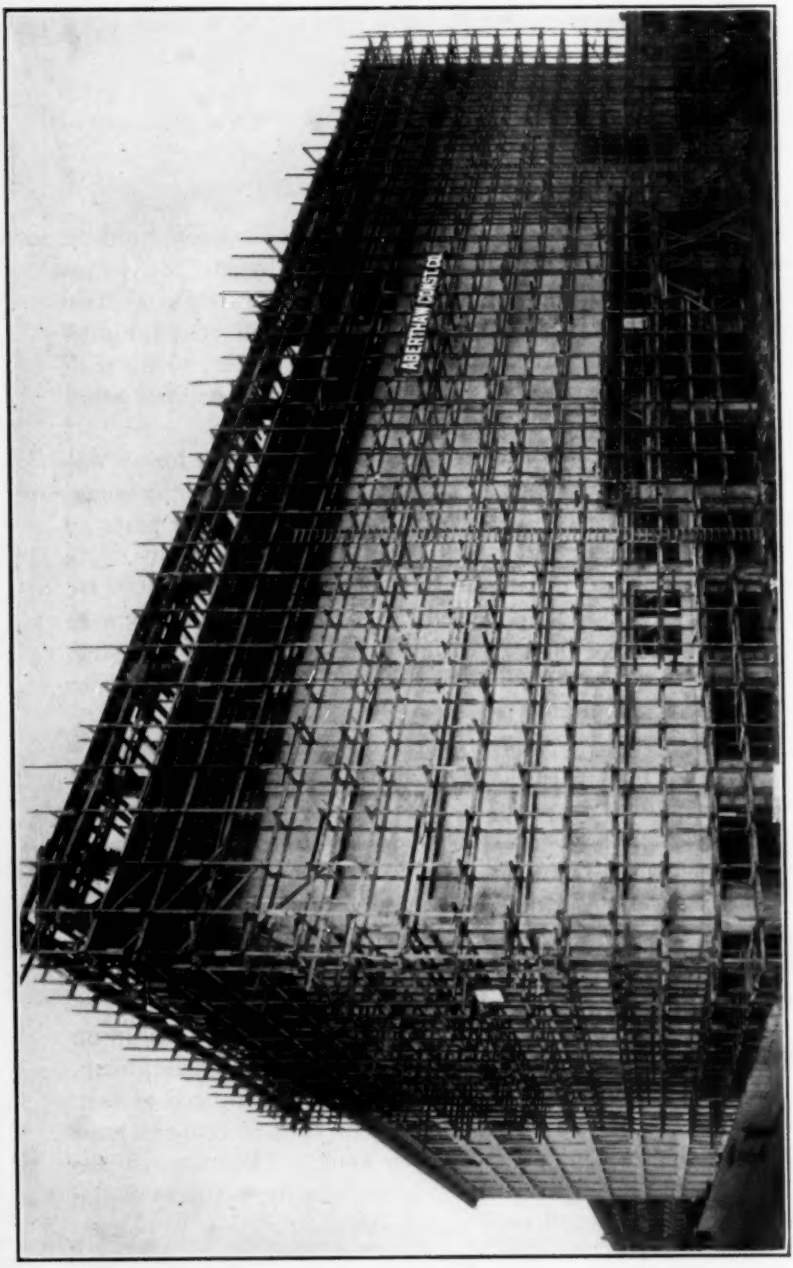


FIG. 1.—COMMONWEALTH ICE AND COLD STORAGE COMPANY'S BUILDING, SOUTH BOSTON, MASS.

Mr. Wason.

On the first job in question, 1,800 sq. ft. of forms were leased and were used on the average $16\frac{1}{4}$ times, with the following results:

	Tower Walls.	
	Wood, 53,081 sq. ft.	Blaw, 18,327 sq. ft.
Make, erect, strip	10.84	12.80
Unload material	0.15	0.15
Rubbish	0.17	0.17
Total labor	11.16	13.12
Lumber or rental	2.91	1.95
Sundry material	0.60	0.60
Total material	3.51	2.55
Plant (labor and material)	0.20	0.05
Comparative cost	14.87	15.72

On the second job, the first set of forms were transferred and enough more were leased to make altogether 20,500 sq. ft. and were used on the average $13\frac{1}{3}$ times. Therefore some of them were used 30 times, and at the completion of the work there was no difference in the appearance of those which had been used only 13 times and those which had been used 30. The results on the second job were as follows:

Make, erect and strip	9.23 cents	
Unload material	0.61 cents	
Total labor		9.84 cents
Rental	2.70 cents	
Sundry material	0.34 cents	
Total material		3.04 cents
Plant (labor and material)		0.05 cents
Total cost		12.93 cents

Attention is called to the material cost, 2.7 cents per sq. ft. Enough wedges and shims were included in the lease price of 30 cents per sq. ft. to set the work up once and a fair allowance over this for loss and breakage. The loss on this item was so great that we had to purchase enough more shims to be equal in price to 6.9 cents per sq. ft. of forms, which, spread over $13\frac{1}{3}$ uses, amounts to 0.52 cents per sq. ft. Thus the 2.7 cents includes 0.5 cent for shims and wedges and 2.2 cents for lease of forms. Although the general average of the whole job, which amounted to 266,905 sq. ft. of wall centered, was 9.23 cents for direct labor due to a number of irregularities; on the plain work which duplicated regularly this cost was reduced to 7.73 cents, and on a part

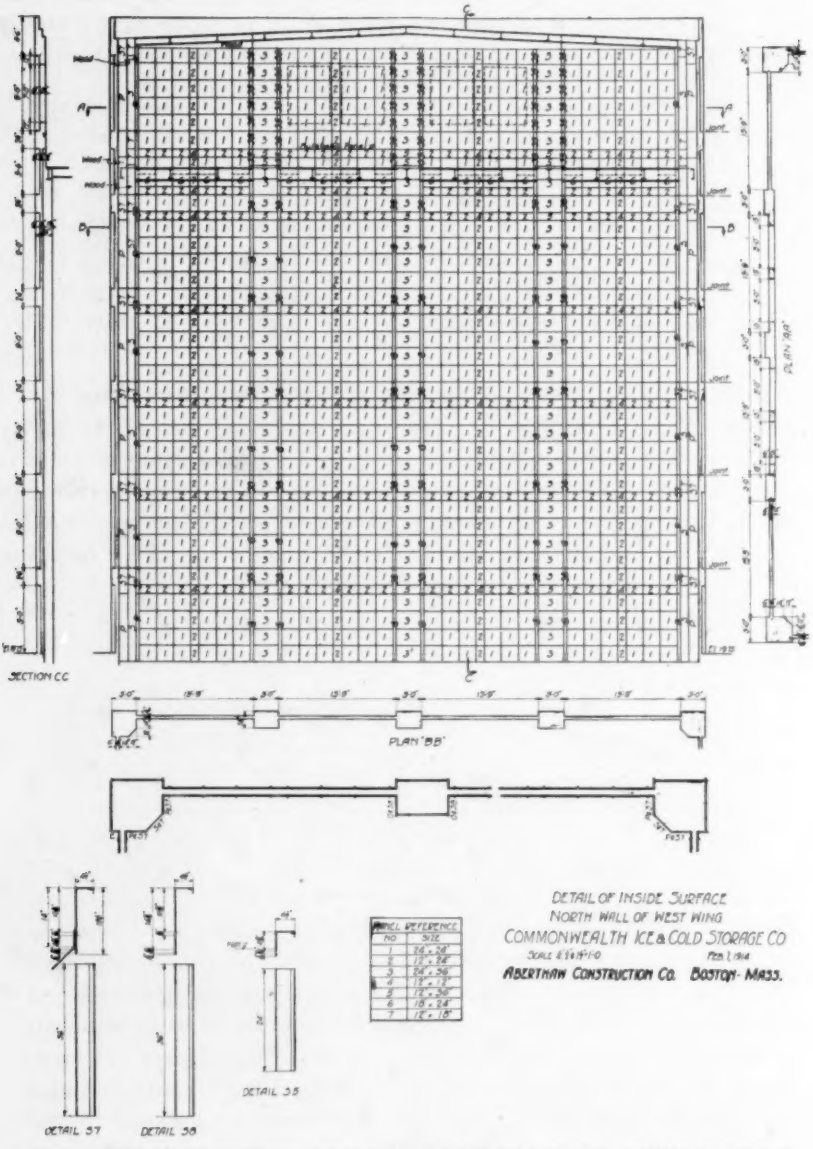


FIG. 2.—DRAWING SHOWING DETAIL REQUIRED IN THE USE OF METAL FORMS.

of the simple work by methods of task and bonus the erection cost only was reduced to the figure previously stated. Mr. Wason.

Fig. 2 reproduces a drawing made in my office, and shows something of the detail required. Every panel joint and member is shown. There are something over 1,100 panels to put up on each side to build a wall about 73 by 100 ft. It necessitates a careful study in the office in advance to get the best results; to be sure that every detail is thoroughly thought out; thought out long enough ahead that the form builders can produce the work in time not to delay actual construction. If a person is willing to go to this trouble, he will be justified in the cost results obtained.

The total cost of steel forms is 30 cents per sq. ft., when they are leased and returned. With wood, on the average, 3 cents or a little less per superficial foot of contact is the cost after spreading the first cost over 4 times used. Thus it is necessary to use steel forms over 10 times to bring the average cost of materials per square foot down to that of wood. Now with wood, the forms are so much shaken and damaged that after 3 or 4 uses they are practically worn out and have to be replaced, while the steel forms on this job were in very good order after an average use of $13\frac{1}{3}$ times.

I have not had the experience of using steel forms to destruction. I have used them 30 times. I consider 45 uses conservative for their life and that during this period probably 3 cents per sq. ft. will be spent for upkeep and that when worn out 0.4 cents a pound, or 3 cents per sq. ft. can be obtained for the metal as junk. Thus if the forms are bought (instead of leased) at 45 cents per sq. ft. the cost per use will be 1 cent per sq. ft. for panels. Adding our past experience with wedges, would thus make the total cost of materials for steel form work 1.5 cents per sq. ft.

The appearance of this particular job is very much better than has been obtained in the past with wood. The lines were true. If you squint up the edges of the columns they look almost as true as they can be made; squint horizontally along the beams, they are also true. The surfaces are smooth, there are none of the irregular corners that you get with boards when they shrink and there is a crack, or where, if a little weak, they spring. It was much easier to finish the surface after the forms were stripped. This work was done and is being done right now at an exposed point on Boston harbor; therefore the work has to be heated.

Mr. Wason. There is more danger, I think, of transmission of the heat to the concrete through steel forms than there is through wood. Salamanders are placed on the stage near new work and unless care is used different parts of the wall are too unevenly heated.

The small wedges and keys which are used are a nuisance. They are so small they are easily lost. On this first job there were three times as many provided as were actually necessary to set up all the forms, and after the workmen set them up four times there were hardly enough to go around the fifth time. More had to be obtained. We tried to save them by putting a man with a pail at the special task of picking them up as soon as they were removed. The bonding and wedging of panels together is something that will have to be carefully studied by the makers and improved upon in some way, so that the keys stay with the plates and will not be lost by falling to the ground.

Mr. Skinner. MR. T. H. SKINNER.—I would like to ask Mr. Wason if the figures given cover the overhead expenses of his office in making the plans for this work.

Mr. Wason. MR. WASON.—They cover only the overhead job cost, that is, office expenses of the job, including superintendent, the timekeepers, watchmen, etc., also the cost of receiving, storing, setting up, taking down and moving to a new position, and their final removal from job.

In regard to making plans such as these and of forms in general, the engineering office expense runs, for a small job, from about 45 cents per 100 sq. ft. of surface contact to about 5 cents on a regularly designed big building. Five cents per 100 sq. ft. you see is too small a cost to worry much about. I might add that a good many years ago when we simply sent a set of blueprints of the building to the foreman and left him to work out his own form designs, column forms used to cost for direct labor as much as 18 cents per sq. ft. and floors 12 cents.

Now we spend much time in the office making plans; sometimes we make as many as forty-five sheets of form details for a simple building. These designs may cost 0.2 cents per sq. ft. of form work. If the cost for labor for floor forms, for instance, runs over 4 cents per sq. ft., we want to know what is the matter, and if it runs over 7 cents for a column we usually make a row. I have always said that a dollar spent in the drafting room usually saves ten on the work, and I think it saves more sometimes.

FULL-SIZE TESTS AND THEIR VALUE IN CONCRETE CONSTRUCTION.

By Burtis S. Brown.*

Testing is one of the branches of engineering in which there has been considerable development during the last 10 years. We have been familiar for many years with laboratory tests, such as are carried on at the various technical schools, and the government testing stations. Supplementing these tests, come those of the newer branch, known as field or full-size tests upon completed structures.

There are many advantages in determining the strength of a structure. It places a premium on good workmanship as well as on good design which the speaker believes is most essential in all reinforced concrete work.

At the 1910 meeting of the Association, Arthur R. Lord gave a paper on the full-size test of the Deere and Webber Company's building; since then about 25 tests have been made and reported, while many others have been made but not reported. It is refreshing to note that several of the large concrete construction companies are conducting tests to prove the merit of their work.

Most of you know that in Chicago, all new systems of flat slab construction of reinforced concrete must be tested by engineering experts selected by the Building Department. Test panels are selected at random by a representative of the Building Department and tested with double the designed load. The results of one of these tests form the basis for future requirements for that particular system.

Many of you were present last year at the Pittsburgh Convention and saw the compression test of the large reinforced concrete column in the 10,000,000-lb. testing machine. Further tests on concrete columns begin next week at Pittsburgh. We are also all familiar with the splendid information given out so freely by the University of Illinois Experiment Station on the results of the testing done under the direction of Arthur N. Talbot.

* Consulting Engineer, Boston, Mass.

There are few tests on concrete bridges. Mr. D. A. Abrams, Engineer for the Illinois State Highway Commission, has designed, and had constructed at one of the Illinois penitentiaries, a 40-ft. span bridge. This the convicts loaded to destruction with gravel and iron. Strain gage readings and deflections were taken. A report of this test can be found in the last volume of Proceedings of the American Society for Testing Materials. Similar work has been attempted on completed steel bridges, but without success, due to difficulty in eliminating temperature stresses.

METHOD OF MAKING LOAD TESTS.

There are three methods of making load tests depending on the size of the floor to be tested, namely, to apply a load to:

(A) A portion of the floor of the completed building.
(B) A single isolated panel (built for test purposes).
(C) The entire floor of continuous spans.

Nearly all the tests conducted have been by method (A), that is, on a portion of a completed building. This is the most logical method, because it is under the actual working conditions. It is not considered good practice to require a test load of more than double the designed load.

Method (B) is satisfactory for structures of wood or steel but does not give results of prime importance for those of reinforced concrete, except for non-continuous spans.

There has been, to the writer's knowledge, only one test made by method (C). That was the test made under his direction at the Worcester Polytechnic Institute at Worcester, Mass., with the co-operation of the University of Illinois.

As mentioned above, completed buildings should not be tested to more than twice their design load, because they are likely to become permanently strained, and it is difficult to repair the damage. A contractor for a structural steel frame would not consent to a test to more than the elastic limit, that is, twice the design load. Testing to ultimate loads, when the strain gage is used for the readings, does not give results of scientific value because the ratio $E=\frac{\text{stress}}{\text{strain}}$ is not constant above the elastic

limit. If a structure is built purposely for testing, it should be located on rigid foundations. The best location is on a ledge. The proportion of over-load for one floor in a finished building is not great, but with a test structure a large factor of safety should be employed in the design of the foundations. It should be located where the loading material can be obtained easily, and also placed on the slab by a crane, derrick, clam-shell or grab-bucket provided with a weighing device. The method of loading used by Mr. Abrams has many excellent features.

SUGGESTIONS FOR TESTING.

To successfully carry out a test of this kind much forethought and study must be given to the details. A schedule should be made out and rigidly followed. On every important test, the writer believes that there should be at least three investigators, one in charge of each branch of the work, namely:

(*a*) Expert in laboratory work; { Observers; two at least, / Recorders; one for each observer, / Calculators.

(*b*) Contractor's representative; { building platforms and observation boxes, / placing load, / removing load.

(*c*) Designing engineer or his representative; { general oversight, / checking load.

The number of men under each investigator depends on the size of the test and the speed with which it must be carried out. It is found that men who are familiar with laboratory work in colleges or in technical schools are more efficient for this sort of work.

Tests by contractors usually show great advantages for their particular system and the results obtained are thus discounted unless carried on by disinterested persons. The presence of independent investigators give the results much greater value as scientific data.

Although hard to regulate, the time of the year is an important factor, in this kind of work. The season when the temperature is uniform, as in the spring and fall, is more advantageous than in the season of extreme heat or cold. Temperature conditions should be very nearly the same for each set of readings.

One of the details requiring much forethought is the location of the gage points where the stresses are to be measured. In

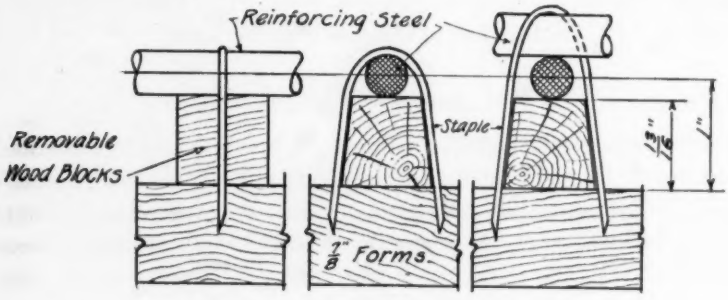


FIG. 1. BLOCKS AT TENSION READING.

each test these locations vary, depending on the ultimate object of the test. It facilitates and also permits better work if the locations for gage readings are given ahead and wooden blocks placed between the steel and the bottom of the slab when the concrete is being poured, as it is difficult to find the rods after they are surrounded by concrete. Also the bond is likely to be injured by too much cutting. Fig. 1 shows the method of locating the gage points for tension readings at the Worcester test. While Fig. 2 shows the details for compression test. Briefly this consisted of a 1 in. length of $\frac{5}{8}$ in. diam. steel rod. This is set in plaster of Paris and drilled after the plaster is hardened.

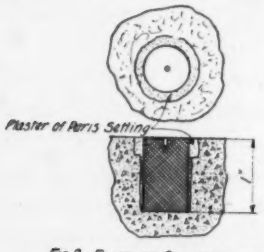
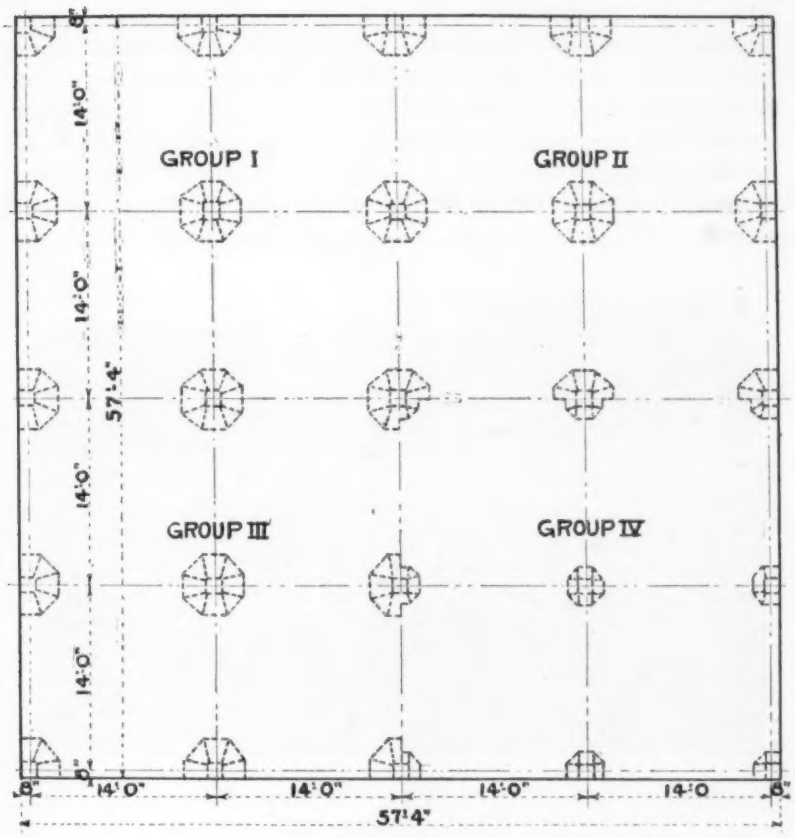


FIG. 2. PLUG AT COMPRESSION READING.

Data sheets to record the readings should be prepared before beginning the tests. A very satisfactory description of the instruments required, is given in Bulletin No. 64 of the University of Illinois.

Precise levels should be taken on all columns under the test



PLAN SHOWING PANEL GROUPING

SECTION OF SLAB SHOWING DIMENSIONS

FIG. 3.—PLAN SHOWING PANEL GROUPING AND GENERAL DIMENSIONS.

load, and also those supporting the adjoining bays. Some apparently erratic results can be explained by settlement of columns. The deflectionmeters should not be depended upon to measure the deflection for any large load in compression. Zero readings should be taken by two independent observers. Any large error will be detected by this precaution. It will also reduce the effect of the personal equation. At each increase of load one set of readings is taken until the final readings are reached. Final readings are observed by two persons. Both sides of the flat slab should be whitened to assist in locating the first occurrence

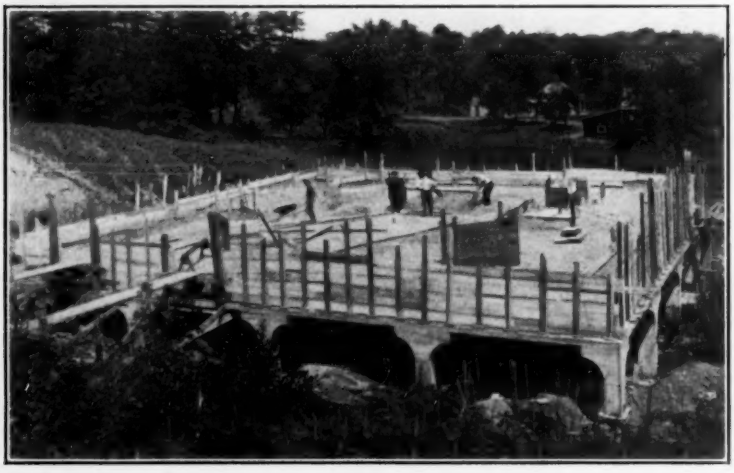


FIG. 4.—VIEW OF WORCESTER TEST SLAB.

of very small cracks. While cracks do not show definitely the exact location of weakness yet they indicate the approximate area of overstrain.

DESCRIPTION OF THE WORCESTER TEST.

The floor built at Worcester in 1913, was unique since it was constructed solely for test purposes. As shown in Fig. 3 there were 16 bays of flat slab construction with column centers 14 ft. apart so that the area of slab supported on the 25 columns was 57 ft. 4 in. sq.

Four different types of construction were designed, each type having one interior bay and three exterior bays. The work was carried on in an entirely unbaised manner, without any desire to prove or disprove any particular theory. In Fig. 4 a general idea can be gained of the method of loading. About 365 tons of gravel was loaded on the slab and strain gage readings were taken at points for four different loadings. The slab broke away from one of the interior and three of the exterior columns. The load has been permitted to remain on the slab through the winter and one corner has completely collapsed.

FUTURE OF TESTING WORK.

It is the writer's opinion that much study and progress will be made in the near future in the methods of making full-size tests. By this means the cost of engineering structures will reduce. The factor of ignorance is one of the most costly items in construction work. This opportunity to save, added to the efficiency system savings will surely be appreciated. The possibilities are unlimited for obtaining data to assist in the design of such indeterminate structures as arches, retaining walls, etc.

DISCUSSION.

Mr. Kerr. MR. H. D. KERR.—I would like to ask Mr. Brown if those steel rods that broke when the overload occurred were the commercial twisted steel rods.

Mr. Brown. MR. B. S. BROWN.—The rods were of mild steel with an elastic limit that varied from 42,200 to 44,400 lb. per sq. in. The slab was $5\frac{1}{4}$ in. thick, with eight $\frac{3}{8}$ in. diam. plain round rods in the cross bands in the sides and eleven $\frac{3}{8}$ in. diam. plain rods in the diagonal bands.

Mr. Mensch. MR. L. J. MENSCH.—Do I understand that these slabs fell under three times the concrete design load?

Mr. Brown. MR. BROWN.—There was one of them that fell under a little more than four times the design load. One of the footings settled. The soil was splendid looking gravel and the load on it was less than 2 tons per sq. ft. There was a soft pocket below one footing. The purpose of this test was not to prove or disprove any particular theory, but to make sure that the design of a big building was all right. A test on an interior panel was desired and that made it necessary to build nine panels; and then it was thought that it might be just as well to build sixteen and secure four interior panels with the corresponding exterior panels. Considerable pressure was brought to bear after all the steel and cement was delivered at the site to build individual panels, of sixteen different kinds, rather than one large continuous floor test with only four kinds. After consultation with Prof. Arthur N. Talbot, Mr. Sanford E. Thompson, Prof. A. W. French and several others, it was decided to continue as originally planned. The design live load was 100 lb. per sq. ft. on the large capitals and about 63 lb. on the small capitals; the latter was an unsymmetrical design in which the steel was much stronger than the concrete. There was one variable in each group, and instead of figuring the amount of steel required, the same amount of steel was used that was used in the slab with the larger capital. It failed between 200 and 250 lb. and so had over four times the design load; the failure was due to the slab breaking. The columns were of reinforced concrete, 14 in. sq.

MR. C. HELLER.—I would like to ask Mr. Brown or any other member present, whether he has ever tried to use the flat slab in tension with a structural column. Mr. Heller.

MR. BROWN.—In the ten-story Paine Building the H section was used. In the East Boston Terminal the H section was also used. In the eight-story Friend Street Building structural steel columns made of the customary plate and four angles were used; all of these were buildings with flat slabs. The Quincy Market has also structural steel columns. Mr. Brown.

MR. HELLER.—What would be the head of the column of the flat slab? Mr. Heller.

MR. BROWN.—Just the same as for any other slab. There is no difficulty; just carry the rods around the structural steel, and build a shelf under the column head at each floor or every other floor to transfer the load into the steel column. The Quincy Market was most unique in that respect. The structural steel column core was star shaped made with four angles back to back and these carried the load introduced at every other floor from the concrete shell that carried the load for two stories. Then around those angles were placed pieces of galvanized iron, so that the steel core acted independently of the concrete. In later designs we depend wholly on the structural steel core to carry the entire load, and the concrete surrounding the steel is simply for fire proofing purposes. Mr. Brown.

MR. T. L. CONDRON.—It seems unfortunate that the author of this paper has not added something about the details of the construction of the slabs tested. What he has told us about the site selected and the general nature of the experiment is interesting, but his paper would have been much more valuable had it included a description of the methods of reinforcing the slabs and the actual results of the tests. He states that the slabs were designed for a live load of 100 lb. per sq. ft. and tested with a load of 300 lb. per sq. ft. It is, therefore, somewhat astonishing to learn that this test load caused the absolute destruction of some, and very serious injury to other panels; for in Chicago we are required to make tests of reinforced concrete floors—using a test load equal to twice the live load plus the dead load—and it frequently happens that slabs designed for 100 lb. live load are tested with practically 500 lb. per sq. ft. under which load Mr. Condron.

Mr. Condron. they show only slight deflections and no signs of permanent injury. In view of the fact that the spans of these slabs were only 14 ft. it is very evident that part of the design, at least, would hardly be considered good for 100 lb. working load. It is hoped that the author will, before his paper is published, add some of this really important data, in order that members of the Institute may gain knowledge from such an extensive experiment.

Mr. Brown. MR. BROWN.—I have tried to tell you just as far as I could the conclusions and the points that I expect to cover in another paper. In digesting this information I find new points are constantly being brought out and it will be better for the profession, to wait until the results of this test are thoroughly digested.

Mr. Anderson. MR. W. P. ANDERSON.—Mr. Brown spoke of determining the stress in the steel by extensometer readings. Now, of course, tests of this kind are very valuable, but a person should not draw wrong conclusions from those readings; as far as I know no tests have been made to determine whether the stress in steel over several inches is uniform. The stretch in that length might indicate a stress of 10,000 lb., but in that distance there may be cracks in the concrete, and at the points where the cracks occur it might be stretched to 20,000 lb. The steel between the cracks adheres to the concrete and the adhesion might affect the expansion of the steel. I do not know whether it affects it or not but until tests are made which determine the effect of the expansion of steel imbedded in concrete in relation to the effect of the expansion when it is not so imbedded, extensometer readings should be taken with allowance for possible error due to the imbedment of the steel. The stretch may be unequal, and if it is unequal there may be certain points where the steel is stressed beyond the amount indicated by the reading.

Mr. Collings. MR. W. A. COLLINGS.—I should like to ask Mr. Brown if the middle panels showed a better general effect than the outside panels. Was there any sympathetic action shown?

Mr. Brown. MR. BROWN.—When the exterior panel gave way, we first noticed a crack in the concrete in the corner column having the small sized capital, and when that broke it affected the interior panel. The cracks were not so numerous in the interior bays. In answer to Mr. Anderson's statement, I will say that we can-

not depend too much upon these extensometer readings. A great deal depends on the use of the instrument, and it requires an expert to use it successfully; but when two independent observers, with two independent instruments, having different ratios, figure the stresses with variations in the results of from 25 to 50 lb. (a great many of which absolutely check), it would seem that this is due to something more than coincidence. We must use common sense in interpreting any readings and the results show that the instrument is fairly correct. Mr. Brown.

MR. ANDERSON.—Mr. Brown does not grasp the point that I endeavored to bring out. I have no doubt that the average of the readings gives the average expansion of the steel, but the point I would bring out is that the expansion for 8 in. may not give the stress at the point where the steel is stretched higher. The effect of the bar of steel in concrete will be a combination of concrete and steel over certain sections. If a crack occurs it would have the tendency to make that a weak section which might be only $\frac{1}{16}$ in., but the stress in that $\frac{1}{16}$ in. might be 2 or 3 times as great as the average stress for the 8 in. What I tried to bring out is that experiments should be made to determine the effect of the elongation over a certain length of steel imbedded in concrete, as compared with the elongation when it is not so imbedded, before definite data as to resultant moments from actual maximum stresses in structures can be obtained. Mr. Anderson.

MR. COLLINGS.—I should like to ask Mr. Brown whether the test that he made as a basis for designing the Paine Building was satisfactory, and whether he tested this building. Mr. Collings.

MR. BROWN.—We designed the Paine Building first and we had the first two or three floors constructed before the test was completed. The building has not been tested. The concrete floors are in, but the rest of the building is not completed. I am so well pleased with the excellent showing in the Worcester Test of the superiority of the four bays similar to the Paine Building that further tests are entirely unnecessary. Mr. Brown.

MR. MENSCH.—I think our President can bring better proof than anybody in this room of the point brought out by Mr. Anderson. I have before me Technological Paper No. 2 of the Bureau of Standards,—by Richard L. Humphrey and Louis H. Losse, in which is recorded tests of 333 beams. Each beam was Mr. Mensch.

Mr. Mensch. tested and the elongation taken both in compression and tension. I suppose they were taken with greater care than could ever be expected in a building. Probably the temperature conditions were also better. I find, for example, beam No. 344 failed at a total load of 6,800 lb. I find that at a load of 4,000 lb., just about 60 per cent of the ultimate load, the extension of the steel was 0.000183 in.; if you multiply this value by 30,000,000, the modulus of elasticity of steel, you obtain a stress of 5,500 lb. The extensometer gives us a stress of 5,500 lb. in this case, at a stage of loading where the factor of safety is only 1.75. I ask you what good are extensometer readings? We believe we have a great factor of safety when we have a stress of 5,500 lb., while actually we have a factor of safety of only 1.75. We do not care what stress we have in our structures, as long as we know we have a large factor of safety. Years ago high grade steel wires were used as concrete reinforcement and a stress of 30,000 lb. per sq. in. was allowed.

Mr. Brown. MR. BROWN.—How are you going to get your bond that way?

Mr. Mensch. MR. MENSCH.—I can suggest many actual tests. In the Matrai system we used steel wire stressed to 30,000 lb. per sq. in. There was only one case to my knowledge in which there was a failure of that system. I cite another test from the above mentioned paper. For example, beam No. 354 failed at 9,600 lb. At a load of 5,000 lb., which is more than 50 per cent of the ultimate load, the stress in the steel was 5,700 lb. The extensometer gives you a stress of 5,700 lb. You certainly would expect a high factor of safety at this low stress but you have only a factor of safety of less than 2. Hence all these extensometer tests, as they are used nowadays, are practically of no value. The only way they would help you is, by making test beams of about the same depth and span at the same time you make the floors and reinforce these beams with the same percentage of steel; where 0.25 per cent of reinforcement is used in the flat slab, use 0.25 per cent in the beams; then load these beams with known loads and find the extensions you obtain with your extensometer under the known loads and known bending moments and test also these beams to destruction. Then you will know your factor of safety, and by comparing the extensometer readings in

Mr. Mensch.

the structure with those in the beams, and by making proper allowances for the various conditions under which the tests are made, you will obtain reliable information. That is the only way you can get reliable tests; tests as made to day, are only money thrown away. And besides, they cause engineers who represent commercial companies to tell engineers and architects, that slab construction, as proposed by them, is proper construction, when in fact the factor of safety is only about 2. Take, for example, the tests made by Mr. Lord in Minneapolis.—if we compare these tests with the information given in Technologic Paper No. 2 there was not a factor of safety of 2. Generally it was declared to be a very good test and to show that flat slabs are reliable. Of course, you might say it is not necessary to have a factor of safety of 4, but this should be clearly understood. There were similar tests on flat slabs, made by others in some of which extensometer stresses of 20,000 lb. per sq. in. were found. What factor of safety have you then, when at 6,000 lb. the extensometer stress is not more than 2? I find a stress of 20,000 lb. at a load of 5,500 lb., that is 80 per cent of the ultimate load, or a factor of safety of $1\frac{1}{4}$.

Mr. Anderson.

MR. ANDERSON.—As possibly some did not understand the point that I wanted to bring out I would like to illustrate it by a rubber band. If you take an elastic band and put court-plaster along its length, so that you have a strip of court-plaster for 1 in. and then you leave a space of $\frac{1}{8}$ in. and put another piece of court-plaster for 1 in. and leave another space of $\frac{1}{8}$ in., etc., and stretch that band between the sections with this restraint of the court-plaster, you would not get as much stretch when the band broke, as you would if the court-plaster was not there. Now when you stretch the steel bar there are sections of the steel bar that are restrained by the concrete which would act as the court-plaster on the elastic band. There are sections where there may be cracks which are equivalent to the free sections of the band. I think that when you stretch a rod in the concrete the result might not be the same as when it is stretched out of the concrete and, therefore, you cannot by using the recognized modulus of elasticity of the steel, determine the stress at the high point, because your extensometer reading is taken over 8 in., and your highpoint may be just a fraction of an inch. Now I do not say

Mr. Anderson. that the effect is very great, because I do not know how great it is. In fact, the effect might prove so small that it could be disregarded; but until tests have been made to show what it is I do not think it ought to be disregarded.

Mr. Brown. MR. BROWN.—In closing, let me repeat that full data and results of the Worcester Test will be made public and I trust every engineer interested will discuss this data. It is only by a full and free discussion that the truth regarding flat slabs will be known. Probably there is no adaptation of concrete today where practice and theory are so much at variance as in the computation of flat slabs. As mentioned previously, this test was carried on by entirely disinterested persons, with material obtainable in the open market. The surprisingly few failures of this type of slab is a tribute to its remarkable strength.

REPORT OF COMMITTEE ON TREATMENT OF CONCRETE SURFACES.

The Committee presents:

1. The following Proposed Revisions of Standard No. 15—Standard Specifications for Portland Cement Stucco:

Page 315, Sec. 4. Line 2—omit words "cow" and "cocoanut."

Sec. 5. Change to read as follows:

"Coloring Matter: Only inorganic colors shall be used which are not affected by lime, Portland cement, other ingredients of the mortar, or the weather."

Page 316, Sec. 8. Line 4—for word "barrel" substitute word "bag."

Line 5. Change "4" to "1."

Page 317, Sec. 17. Line 1—omit word "strip" and for words "form an" substitute words "forms a," and omit word "integral," making line 1 read: "When furring forms a part of the, etc."

Line 2—omit word "strips."

Line 3—for word "are" read "is."

Sec. 17 (*a*). Line 1—omit word "strips."

Sec. 17 (*b*). Change first sentence to read: "Galvanized or painted $\frac{1}{2}$-in. crimped furring, not lighter than 22 gage or other shape giving equal results, shall be fastened over the sheathing paper and directly along the line of the studs, using $1\frac{1}{4}$-in. x 14 gage staples placed 12 in. apart."

Page 318, Sec. 17 (*b*). Next to last line—omit word "strips."

Sec. 20. Line 2—omit word "strips."

Line 3—omit word "strips."

Page 319, Sec. 23. Last line of 2d paragraph—change period to comma and add, "and shall be in this condition when the plaster is applied."

Page 320, Sec. 25. Par. 5—Change to read: "If subsequent coats are applied they shall be well troweled to insure good bond with the previous coat."

Page 322, Sec. 38. Par. 2, line 4—omit words "and lime."

Line 6—Before word "water" insert words "Lime putty, if used, and."

Page 323, Sec. 40. Line 1—omit word "a" and word "strip."

Line 7—omit word "strip" and change word "are" to "is."

Sec. 41. Omit word "strips" in Lines 2, 5, 7 and 2d Par., line 1.

2. Proposed Standard Specifications for Portland Cement Stucco on Wood Lath.

Respectfully submitted,

LEONARD C. WASON, *Chairman.*
CLOYD M. CHAPMAN,
L. R. FERGUSON,
H. B. MCMASTER,
J. C. PEARSON.

AMERICAN CONCRETE INSTITUTE

Founded 1905 and Incorporated 1906, as
NATIONAL ASSOCIATION OF CEMENT USERS
Charter Amended July 2, 1913.

PHILADELPHIA, PA.

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT STUCCO.

Paragraphs marked (*a*) apply only to back-plastered walls without sheathing.
Paragraphs marked (*b*) apply only to walls with sheathing.
All other paragraphs apply to both forms of construction.

MATERIALS.

1. *Cement.*—The cement shall meet the requirements of the Standard Specifications for Portland Cement of the American Society for Testing Materials, and adopted by this Institute (Standard No. 1).

2. *Fine Aggregate* shall consist of sand, crushed stone, or gravel screenings, graded from fine to coarse, passing when dry a screen having ¼ in. diameter holes, shall be preferably of silicious materials, clean, coarse, free from loam, vegetable or other deleterious matter.

3. *Lime.*—The lime shall be thoroughly hydrated either by the manufacturer, or the contractor. If hydrated by the contractor, it shall be slaked in sufficient water to make a soft paste and allowed to stand at least one week before being applied to the wall.

4. *Hair or Fiber.*—There shall be used only first quality long hair, free from foreign matter, or a long fiber well combed out.

5. *Coloring Matter.*—Only inorganic colors shall be used which are not affected by lime, Portland cement, other ingredients of the mortar, or the weather.

6. *Water* shall be clean, free from oil, acid, strong alkalies or vegetable matter.

PREPARATION OF MORTAR.

7. *Mixing.*—The ingredients of the mortar shall be thoroughly mixed to a uniform color, sufficient water added to obtain the desired consistency, and the mixing shall continue until the cement and lime are uniformly distributed and the mass is uniform in color and homogeneous.

The hair or fiber shall be added during the process of wet mixing.

8. *Measuring Proportions.*—Methods of measurement of the proportions of the various ingredients, including the water, shall be used which will secure separate uniform measurements at all times. All proportions stated are by volume. A bag of cement (94 lb. net) shall be assumed to contain 1 cu. ft. Lime when used shall be measured in the form of putty. Hydrated lime shall be made into putty before being measured.

9. *Quantity.*—There shall not be mixed at one time more mortar than will be used within one hour. Mortar which has begun to stiffen or take on its initial set shall not be used.

10. *Hand Mixing.*—The mixing shall be done on a water-tight platform and the materials shall be turned until they are homogeneous in appearance and color.

11. *Consistency.*—The materials shall be mixed so as to provide sufficient water to insure a proper bonding and a dense mortar free from voids.

12. *Retempering.*—Retempering mortar, *i.e.*, remixing with water after it has partially set, shall not be allowed.

STRUCTURE.

13. *Framing.*—Studs spaced at 12-in. centers wherever possible shall be run from foundation to rafters without any intervening horizontal grain in the wood. These studs shall be tied together just below the floor joists by 6-in. boards which will be let into the studs on their inner side, so as to be flush and securely nailed to them. These boards will also act as sills for the floor joists, which in addition will be securely spiked to the side of the studs.

14. *Bracing.*—The frame of the building shall be so rigidly constructed and braced as to avoid cracking the stucco.

(*a*) At least once between each two floors, brace between the studding with 2 x 3 in. bridging.

(*b*) Bracing may be omitted, as the sheathing boards act as bracing.

15. *Sheathing.*—(*a*) The lath is to be fastened direct to the studding and back-plastered and no sheathing boards are to be used.

(*b*) Sheathing boards shall be not less than 6 in. or more than 8 in. wide, dressed on one or both sides to a uniform thickness of $\frac{7}{8}$ in. They shall be laid diagonally across the wall studs and fastened with two nails at each stud.

16. *Inside Waterproofing.*—(*a*) The faces of the studs and for one inch back of the face on each side where the plaster may come in contact with them, shall be thoroughly waterproofed with tar or asphalt.

(*b*) Over the sheathing boards shall be laid in horizontal layers, beginning at the bottom, a substantial paper well impregnated and thoroughly waterproofed with tar or asphalt. The bottom strip shall lap over the base board at the bottom of the wall, and each strip shall lap the one below at least 2 in. The paper shall lap the flashings at all openings. When required, the lower horizontal edge of each strip shall be cemented with hot or liquid tar or asphalt compound, to the strip below and to the grounds of flashings at all openings. All tacking shall be within 2 in. of the top horizontal edge, where tacks will be covered by the lap of the strip above.

17. *Furring.*—When furring forms a part of the metal lath to be used, then separate furring as described in this paragraph is to be omitted.

(*a*) Galvanized or painted $\frac{1}{2}$-in. crimped furring, not lighter than 22 gage or other shape giving equal results, shall be fastened direct to the studding, using $1\frac{1}{4}$-in. x 14 gage staples, placed 12 in. apart.

(*b*) Galvanized or painted $\frac{1}{2}$-in. crimped furring, not lighter than 22 gage or other shape giving equal results, shall be fastened over the sheathing paper and directly along the line of the studs, using $1\frac{1}{4}$-in. x 14 gage staples, placed 12 in. apart. The same depth of furring should be adhered to around curved sur-

faces, and furring shall be placed not less than 1½ in. or more than 4 in. on each side of and above and below all openings.

18. *Preparation of Original Surface.*—All roof gutters shall be fixed and down-spout hangers and all other fixed supports and fasteners shall be put up before the plastering is done, so there will be no break made in the plastering where they are permanently fixed.

Wall copings, balustrade rails, chimney caps, cornices, etc., shall be built of concrete, stone, tile or metal with ample overhang drip grooves or lip, and water tight joints, to keep water from behind the plaster.

If wood sills are used, they should project well from the face of the plaster and have ample drip groove or lip.

Metal lath shall be stopped far enough above the level of the ground to be free from ground moisture.

Care should be taken to provide for placing all trim the proper distance from the studding or furring to show its right projection after the plaster is on.

19. *Lath.*—The lath shall be not thinner than 24 gage, galvanized or painted, expanded metal lath weighing not less than 3¼ lb. to the square yard, or woven wire lath, galvanized or painted, 19 gage, 2½ meshes to the inch, with stiffeners at 8-in. centers.

20. *Application of Lath.*—Place lath horizontally over the furring, driving galvanized staples, 1¼-in. x 14 gage, 8 in. apart over the furring into the studding. The sheets of lath shall be locked or lapped at least 1 in. and tied at joints between studs both vertically and horizontally with 18 gage wire.

21. *Corners.*—There shall be 6-in. strips of metal lath bent around the corners and stapled over the lath, or the sheets of metal lath shall be folded around the corners a distance of at least 3 in. and stapled down, as applied. Galvanized corner bead may be applied over the lath.

22. *Insulation.*—(*a*) After the lath on the outside has been back-plastered, the air space may be divided by applying heavy building paper, quilting, felt or other suitable insulating material between the studs, fastening it to the studs by nailing wood strips over folded ends of the material. This insulation should be so fastened as to clear the bridging, leaving the preponderance of the air space next to the plaster. Care must be taken to keep

the insulating material clear of the outside plaster and to make tight joints against the wood framing at the top and bottom of the spaces and against the bridging where the face intercepts.

(*b*) When quilting, felt, or other insulating material is to be used it shall be applied to the sheathing boards under the inside waterproofing.

23. *Brick, Tile or Cement Block Surfaces.—Existing surfaces* to be stuccoed shall have all loose, friable or soft mortar removed from the joints to a depth of not less than ½ in. All dirt, dust or any other foreign matter shall be removed by means of a wire brush, stiff broom or other effective means. In case the surface has been painted, is oily or otherwise in such condition that the stucco will not firmly adhere, then metal furring and lathing shall first be applied.

New surfaces shall have ample roughness to assure a strong bond and key between the stucco and the surface. The mortar joints shall not be less than ⅜ in. thick and the mortar shall be omitted from or raked out of the joints for at least ½ in. back from the face to which the stucco is applied. Before placing the scratch coat the surface shall be brushed clean from all dust, dirt or loose particles and thoroughly wetted, and shall be in this condition when the plaster is applied.

MORTAR COATS.

24. *Plaster.*—(*a*) The *first coat* shall contain not more than two and one-half (2½) parts of sand to one (1) part of Portland cement by volume. If lime putty is added, it shall not be in excess of one-third (⅓) of the volume of cement. Hair or fiber may be added in sufficient quantity to bond the mortar.

(*b*) The *first coat* shall contain not more than two and one-half (2½) parts of sand to one (1) part of Portland cement by volume. If lime putty is added it shall not be in excess of one-third (⅓) of the volume of cement. No hair, fiber or similar material of any kind or in any quantity shall be added to the mortar.

For *second coat*, the proportion of sand to cement shall not be greater than 2½ to 1 by volume, nor shall more than ⅓ part of lime putty be added.

For *third coat*, the proportion of sand to cement shall not be less than 2 to 1 nor more than 2½ to 1, by volume, nor shall more than ⅓ part of lime putty be added.

25. *Application.*—The plastering should be carried on continuously in one general direction, without allowing the plaster to dry at the edge. If it is impossible to work the full width of the wall at one time, the joint should be at some natural division of the surface, such as a window or door.

Metal Lath.—(*a*) The first coat shall be applied to the lath and pushed through sufficiently to give a good key. Over the face of the studs the plaster shall be forced well through the lath in order to fill entirely the space between the lath and the stud. The backing coat shall be applied to the back of the lath and shall be thoroughly troweled so that the lath shall be entirely covered. The final coat shall be applied to the face of the first coat.

(*b*) The first coat shall be applied to the lath and thoroughly pushed through against the inside waterproofing so as to completely imbed the metal of the lath on both sides. Special care shall be taken to fill all voids around furring strips and where laths lap.

Brick, Tile or Cement Block Surfaces.— The first coat shall be forcibly and thoroughly troweled into the depressions of the previously saturated surface so as to make a firm bond. Care shall be taken to insure the complete filling by the mortar of all crevices and pores.

If subsequent coats are applied they shall be well troweled to insure good bond with the previous coat.

26. *Roughing.*—Soon after applying and before the initial set has taken place, the surface of the coats which are to receive succeeding coats shall be roughened with a saw-toothed paddle or other suitable device.

27. *Dampening.*—Before applying mortar the surface of the preceding coat shall be thoroughly wetted to prevent absorption of water from the fresh mortar.

28. *Thickness of Coats.*—(*a*) The first coat shall be at least $\frac{3}{8}$ in. thick over the face of the lath and project through behind the lath about $\frac{3}{8}$ in. The backing coat shall increase the thickness behind the lath to not less than $\frac{5}{8}$ in. The final coat shall be not less than $\frac{3}{8}$ in. thick.

(*b*) The first coat shall have a minimum thickness over the lath at any point of not less than $\frac{1}{4}$ in. The intermediate coat shall have a thickness of not less than $\frac{1}{4}$ in. or more than $\frac{3}{8}$ in.

The final coat shall have a thickness of $\frac{1}{4}$ in. when placed over an intermediate coat, or of $\frac{3}{8}$ in. when placed directly on the scratch coat.

29. *Drying Out.*—The final coat shall not be permitted to dry out rapidly, and adequate precaution shall be taken, either by sprinkling frequently after the mortar has set hard enough to permit it or by hanging wet burlap or other material over the surface.

30. *Freezing.*—Stucco should never be applied when the temperature is below freezing.

FINISH.

31. *Smooth Troweled.*—The finishing coat shall be troweled smooth with a metal trowel with as little rubbing as possible.

32. *Stippled.*—The finishing coat shall be troweled smooth with a metal trowel with as little rubbing as possible, and then shall be lightly patted with a brush of broom straw to give an even, stippled surface.

33. *Sand Floated.*—The finishing coat, after being brought to a smooth, even surface, shall be rubbed with a circular motion of a wood float with the addition of a little sand to slightly roughen the surface. This floating shall be done when the mortar has partially set.

34. *Sand Sprayed.*—After the finishing coat has been brought to an even surface, it shall be sprayed by means of a wide, long fiber brush—a whisk-broom does very well—dipped into a creamy mixture of equal parts of cement and sand, mixed fresh every 30 minutes and kept well stirred in the bucket by means of the whisk-broom or a paddle. This coating shall be thrown forcibly against the surface to be finished. This treatment shall be applied while the finishing coat is still moist and before it has attained its final set, *i.e.*, within 3 to 5 hours. To obtain lighter shades, add hydrated lime of 5 to 15 per cent of the volume of the cement.

35. *Splatter Dash or Rough Cast.*—After the finishing coat has been brought to a smooth, even surface and before attaining final set, it shall be uniformly coated with a mixture of 1 part cement and 2 parts of sand thrown forcibly against it to pro-

duce a rough surface of uniform texture when viewed from a distance of 20 ft. Special care shall be taken to prevent the rapid drying out of this finish.

36. *Pebble Dash.*—After the finishing coat has been brought to a smooth, even surface, and before attaining initial set, clean round pebbles or other material as selected, not smaller than $\frac{1}{4}$ in. or larger than $\frac{3}{4}$ in., previously wetted, shall be thrown forcibly against the mortar so as to imbed themselves in the fresh mortar. They shall be distributed uniformly over the surface of the final coat and may be pushed back into the mortar with a clean wood trowel, but no rubbing of the surface shall be done after the pebbles are imbedded.

37. *Exposed Aggregates.*—The finishing coat shall be composed of an approved, selected coarse sand, marble dust, granite dust or other special material, in the proportion given for finishing coats, and within 24 hours after being applied and troweled to an even surface, shall be scrubbed with a stiff brush and water. In case the cement is too hard a solution of 1 part hydrochloric acid in 4 parts of water by volume can be used in place of water. After the aggregate particles have been uniformly exposed by scrubbing, particular care shall be taken to remove all traces of the acid by thorough spraying with a hose.

38. *Mortar Colors.*—When it is required that any of the above finishes shall be made with colored mortar, not more than 6 per cent of the weight of Portland cement shall be added to the mortar in the form of finely ground coloring matter.

A predetermined weight of color shall be added dry to each batch of dry fine aggregate before the cement is added. The color and fine aggregate shall be mixed together and then the cement mixed in. The whole shall then be thoroughly mixed dry by shoveling from one pile to another through a $\frac{1}{4}$-in. mesh wire screen until the entire batch is of uniform color. Lime putty, if used, and water shall then be added to bring the mortar to a proper plastering consistency.

MACHINE STUCCO.

39. Stucco may be applied by a machine provided the results obtained are equal to those produced by hand work.

OVERCOATING.

During recent years there has come into vogue a method of remodeling old frame houses. This "overcoating," as it is called, is used extensively in all sections of the country and the following practice is recommended:

40. Where furring is used so deep that the space back of the lath is not entirely filled with plaster, some provision must be made for extending the old window and door frames to correspond with the increased thickness of the wall. In some cases the plaster is brought over the old frames in such a manner that a recessed window or door opening is made. In case the furring is fastened to the studding, it is not necessary to provide for extending the window and door frames, as the new stucco finish will have the same relations as the old weather-boarding.

41. *Preparation of Original Surface.*—If the weather-boarding is in poor condition it should be removed and furring and metal lath applied over the sheathing, to which waterproof paper has previously been fastened. It may be advisable also to tear off the sheathing, in which case the furring can be fastened direct to the studding after bracing between the studs.

Another method would be to fasten the furring direct over the weather-boarding over which the metal lath is applied.

In preparation for any of these methods the house should be gone over carefully to determine if the framework is well enough preserved to justify the improvement.

The doors should be looked after, the studding inspected, partitions and outside walls lined up and brought into plumb.

42. *Furring.*—Fasten galvanized or painted ½-in. crimped furring or other shape giving equal results, vertically over the original surface, which ever of the above may be adopted.

43. *Lathing and Plastering.*—Follow the above specifications for stucco.

AMERICAN CONCRETE INSTITUTE

Founded 1905 and Incorporated 1906, as
NATIONAL ASSOCIATION OF CEMENT USERS
Charter Amended July 2, 1913.

PHILADELPHIA, PA.

PROPOSED STANDARD SPECIFICATIONS FOR PORTLAND CEMENT STUCCO ON WOOD LATH.

Paragraph marked (*a*) applies only to single layer work.
Paragraph marked (*b*) applies only to double layer work.

MATERIALS.

1. *Cement.*—The cement shall meet the requirements of the Standard Specifications for Portland Cement of the American Society for Testing Materials, and adopted by this Institute (Standard No. 1).

2. *Fine Aggregate* shall consist of sand, crushed stone, or gravel screenings, graded from fine to coarse, passing when dry a screen having $\frac{1}{8}$ in. diameter holes, shall be preferably of silicious materials, clean, coarse, free from loam, vegetable or other deleterious matter.

3. *Lime.*—The lime shall be thoroughly hydrated either by the manufacturer, or the contractor. If hydrated by the contractor, it shall be slaked in sufficient water to make a soft paste and allowed to stand at least one week before being applied to the wall.

4. *Hair or Fibre.*—There shall be used only first quality long hair, free from foreign matter, or a long fibre well combed out.

5. *Coloring Matter.*—Only inorganic colors shall be used, which are not affected by lime, Portland cement, other ingredients of the mortar or the weather.

6. *Water* shall be clean, free from oil, acid, strong alkalies or vegetable matter.

PREPARATION OF MORTAR.

7. *Mixing.*—The ingredients of the mortar shall be thoroughly mixed to a uniform color, sufficient water added to obtain the desired consistency, and the mixing shall continue until the cement and lime are uniformly distributed and the mass is uniform in color and homogeneous.

The hair or fibre shall be added during the process of wet mixing.

8. *Measuring Proportions.*—Methods of measurement of the proportions of the various ingredients, including the water, shall be used which will secure separate uniform measurements at all times. All proportions stated are by volume. A bag (94 lb. net) of cement shall be assumed to contain 1 cu. ft. Lime when used shall be measured in the form of putty. Hydrated lime shall be made into putty before being measured.

9. *Quantity.*—There shall not be mixed at one time more mortar than will be used within one hour. Mortar which has begun to stiffen or take on its initial set shall not be used.

10. *Hand Mixing.*—The mixing shall be done on a water-tight platform and the materials shall be turned until they are homogeneous in appearance and color.

11. *Consistency.*—The materials shall be mixed so as to provide sufficient water to insure a proper bonding and a dense mortar free from voids.

12. *Retempering.*—Retempering mortar, *i. e.*, remixing with water after it has partially set, shall not be allowed.

STRUCTURE.

13. *Framing.*—Studs spaced at not more than 16 in. on centers shall be run from foundation to rafters without any intervening horizontal grain of the wood. These studs shall be tied together just below the floor joists by 6-in. boards which will be let into the studs on their inner side, so as to be flush and securely nailed to them. These boards will also act as sills for the floor joists, which in addition will be securely spiked to the side of the studs.

14. *Sheathing.*—Sheathing boards shall be not less than 6 in. or more than 8 in. wide, dressed on one or both sides to a uniform

thickness of $\frac{7}{8}$ in. They shall be laid diagonally across the wall studs and fastened with two nails at each stud.

15. *Insulation.*—When quilting, felt, or other insulating material is to be used it shall be applied to the sheathing boards under the inside waterproofing.

16. *Inside Waterproofing.*—Over the sheathing boards shall be laid in horizontal layers, beginning at the bottom, a substantial paper well impregnated and thoroughly waterproofed with tar or asphalt. The bottom strip shall lap over the base board at the bottom of the wall, and each strip shall lap the one below at least 2 in. The paper shall lap the flashings at all openings. When required, the lower horizontal edge of each strip shall be cemented with hot or liquid tar or asphalt compound, to the strip below and to the grounds of flashings at all openings. All tacking shall be within 2 in. of the top horizontal edge, where tacks will be covered by the lap of the strip above.

17. *Furring.*—Furring $\frac{7}{8}$ in. thick by 2 in. wide shall be laid vertically 12 in. on centers over sheathing paper and nailed every 8 in. with 5*d* nails.

18. *Preparation of Original Surface.*—All roof gutters shall be fixed and down-spout hangers and all other fixed supports and fasteners shall be put up before the plastering is done, so there will be no break made in the plastering where they are permanently fixed.

Wall copings, balustrade rails, chimney caps, cornices, etc., shall be built of concrete, stone, tile or metal with ample overhang drip grooves or lip, and water tight joints, to keep water from behind the plaster.

If wood sills are used, they should project well from the face of the plaster and have ample drip groove or lip.

Lath shall be stopped far enough above the level of the ground to be free from ground moisture.

Care should be taken to provide for placing all trim the proper distance from the studding or furring to show its right projection after the plaster is on.

19. *Lath.*—The lath shall be standard quality, narrow plastering lath 4 ft. long and not less than $\frac{3}{8}$ in. thick.

20. *Application of Lath.*—(*a*) Single layer work. Lath shall be placed horizontally on the furring with $\frac{1}{2}$ in. openings between

them. Joints shall be broken every twelfth lath. They shall be nailed at each furring with 4*d* galvanized nails.

(*b*) Double layer work. The lath shall be applied in two layers. Both layers shall be placed diagonally to the furring in opposite directions, the angle being such that the 4 ft. lath will span three spaces between furring. The space between lath for key shall be 1 in. in each layer. Joints shall be broken every twelfth lath in each layer. The first layer shall be applied directly to the furring and nailed with 4*d* galvanized nails at every point of contact. A second layer of lath shall be applied over the first with joints broken; *i. e.*, ends of lath of the second layer shall not come over the same furring as those of the first layer. The second layer shall be nailed to each furring with 4*d* galvanized nails.

21. *Corners and Openings.*—Around all openings and bent-over corners place a 6-in. strip of galvanized metal lath firmly stapled over wood lath with $1\frac{1}{4}$-in. x 14 gage galvanized staples.

22. *Spraying.*—Wet lath thoroughly on both sides and allow water to be absorbed before applying the first coat of plaster.

MORTAR COATS.

23. *Plaster.*—The *first coat* shall contain not more than two and one-half ($2\frac{1}{2}$) parts of sand to one (1) part of Portland cement by volume. If lime putty is added, it shall not be in excess of one-third ($\frac{1}{3}$) of the volume of cement. Hair or fibre may be added in sufficient quantity to bond the mortar.

For *second coat*, the proportion of sand to cement shall not be greater than $2\frac{1}{2}$ to 1 by volume, nor shall more than $\frac{1}{3}$ part of lime putty be added.

For *third coat*, the proportion of sand to cement shall not be less than 2 to 1 nor more than $2\frac{1}{2}$ to 1, by volume, nor shall more than $\frac{1}{3}$ part of lime putty be added.

24. *Application.*—The plastering should be carried on continuously in one general direction, without allowing the plaster to dry at the edge. If it is impossible to work the full width of the wall at one time, the joint should be at some natural division of the surface, such as a window or door.

The first coat shall be applied to the outside of the lath and pushed through sufficiently to give a good key. If subse-

quent coats are applied they shall be well troweled to insure good bond with the previous coat.

25. *Roughing.*—Soon after applying and before the initial set has taken place, the surface of the coats which are to receive succeeding coats shall be roughened with a saw-toothed paddle or other suitable device.

26. *Dampening.*—Before applying mortar the surface of the preceding coat shall be thoroughly wetted to prevent absorption of water from the fresh mortar.

27. *Thickness of Coat.*—The first coat shall have a minimum thickness over the lath at any point of not less than $\frac{1}{4}$ in. The intermediate coat shall have a thickness of not less than $\frac{1}{4}$ in. or more than $\frac{3}{8}$ in. The final coat shall have a thickness of $\frac{1}{4}$ in. when placed over an intermediate coat, or of $\frac{3}{8}$ in. when placed directly on the scratch coat.

28. *Drying Out.*—The final coat shall not be permitted to dry out rapidly and adequate precaution shall be taken, either by sprinkling frequently after the mortar has set hard enough to permit it or by hanging wet burlap or other material over the surface.

29. *Freezing.*—Stucco should never be applied when the temperature is below freezing.

FINISH.

30. *Smooth Troweled.*—The finishing coat shall be troweled smooth with a metal trowel with as little rubbing as possible.

31. *Stippled.*—The finishing coat shall be troweled smooth with a metal trowel with as little rubbing as possible, and then shall be lightly patted with a brush of broom straw to give an even, stippled surface.

32. *Sand Floated.*—The finishing coat, after being brought to a smooth, even surface, shall be rubbed with a circular motion of a wood float with the addition of a little sand to slightly roughen the surface. This floating shall be done when the mortar has partially set.

33. *Sand Sprayed.*—After the finishing coat has been brought to an even surface, it shall be sprayed by means of a wide, long fibre brush—a whisk-broom does very well—dipped into a creamy mixture of equal parts of cement and sand, mixed fresh every

30 minutes and kept well stirred in the bucket by means of the whisk-broom or a paddle. This coating shall be thrown forcibly against the surface to be finished. This treatment shall be applied while the finishing coat is still moist and before it has attained its final set, *i. e.*, within 3 to 5 hours. To obtain lighter shades add hydrated lime of 5 to 15 per cent of the volume of the cement.

34. *Splatter Dash or Rough Cast.*—After the finishing coat has been brought to a smooth, even surface and before attaining final set, it shall be uniformly coated with a mixture of 1 part cement and 2 parts of sand thrown forcibly against it to produce a rough surface of uniform texture when viewed from a distance of 20 ft. Special care shall be taken to prevent the rapid drying out of this finish.

35. *Pebble Dash.*—After the finishing coat has been brought to a smooth, even surface, and before attaining initial set, clean round pebbles or other material as selected, not smaller than $\frac{1}{4}$ in. or larger than $\frac{3}{4}$ in., previously wetted, shall be thrown forcibly against the mortar so as to embed themselves in the fresh mortar. They shall be distributed uniformly over the surface of the final coat and may be pushed back into the mortar with a clean wood trowel, but no rubbing of the surface shall be done after the pebbles are embedded.

36. *Exposed Aggregates.*—The finishing coat shall be composed of an approved, selected coarse sand, marble dust, granite dust or other special material, in the proportion given for finishing coats and within 24 hours after being applied and troweled to an even surface, shall be scrubbed with a stiff brush and water. In case the cement is too hard a solution of one part hydrochloric acid in four parts of water by volume can be used in place of water. After the aggregate particles have been uniformly exposed by scrubbing, particular care shall be taken to remove all traces of the acid by thorough spraying with a hose.

37. *Mortar Colors.*—When it is required that any of the above finishes shall be made with colored mortar, not more than 6 per cent of the weight of Portland cement shall be added to the mortar in the form of finely ground coloring matter.

DISCUSSION.

Mr. Lazell.

MR. E. W. LAZELL (*by letter*).—It is stated in Paragraph 8, on page 316 of the proposed Standard Specifications for Portland Cement Stucco, that "hydrated lime shall be made into a putty before being measured." It appears to me this is an unnecessary hardship since hydrated lime has been slacked thoroughly by the manufacturer and it can be more conveniently mixed with the sand and cement in the dry form than after it has been made into a putty. In fact it is the common practice on all stucco work that has come under my attention, in which hydrated lime and Portland cement were used, to proportion and mix the ingredients dry, and then add the water; in fact on all first-class work it is becoming the custom to do the mixing with a mortar mixer. Carrying out the above ideas, I suggest that Paragraph 3, page 315, be made to read as follows:

"Either hydrated lime or quicklime may be used. If quicklime is used, it shall be slacked with sufficient water to make a soft paste and allowed to stand at least one week before being applied to the wall."

In Paragraph 8, page 316, strike out all after the word "Lime," in the fifth line, and substitute the following:

"A 100-lb. sack of hydrated lime contains 2¼ cu. ft. If quicklime is used, it shall be measured in the form of a putty, hydrated lime being measured dry as received."

The President.

PRESIDENT HUMPHREY.—I would suggest that the communication of Dr. Lazell be referred to the committee with instructions to thresh the matter out with him, and whatever they agree on be incorporated in the specification.

Mr. Boyer.

MR. EDWARD D. BOYER.—That is satisfactory to me. I am not interested in the hydrated lime at all, but Dr. Lazell states that the use of hydrated lime in the form of putty is apt to pit in the wall. I do not understand that is correct. In the proper process of making the hydrated lime it is at least slacked sufficiently, and I have never seen a case where the pitting of stucco was occasioned by the use of hydrated lime with the cement. For that reason I would like to see the matter gone into further.

MR. WILLIAM M. KINNEY.—I suggest that after the words "a bag of cement" there be added in parenthesis the words "94 lb. net." Mr. Kinney.

MR. PERCY H. WILSON.—I agree that the words "94 lb. net" added after the words "a bag of cement" make it more clear. If the amount of hydrated lime is based on the volume of cement used in the United States the volume would vary considerably from that in Canada, where a bag of cement weighs only 83½ lb. Mr. Wilson.

MR. LEONARD C. WASON.—There certainly would be a variation. This specification was written primarily for the United States. If it is to be recommended for adoption in Canada corrections in the proportioning in paragraph 24 should be made. I think that the insertion of the weight in our American specifications would be unnecessary. Mr. Wason.

PRESIDENT HUMPHREY.—I cannot see any objection to the insertion of the weight 94 lb. so there should be no ambiguity as to what a bag means. The President.

MR. R. C. STUBBS.—I believe that the cement companies will in time give us 1 cu. ft. to the bag and then we will have about 100 lb. We say a bag of cement equals 1 cu. ft. The engineers say a barrel equals about 3.8 cu. ft. and they are right. Therefore, a bag does not contain 1 cu. ft., it contains a fraction thereof. Mr. Stubbs.

MR. BOYER.—This paragraph says it shall be assumed to contain 1 cu. ft. Mr. Boyer.

MR. WILSON.—The number of pounds contained in a bag is pretty well known to be 94; but no one knows how much a cubic foot of cement weighs. Mr. Wilson.

MR. BOYER.—I move that the paragraph be corrected by inserting in parenthesis (94 lb. net). Mr. Boyer.

PRESIDENT HUMPHREY.—Those in favor of inserting "94 lb. net" in parenthesis after the word "bag" please signify it by saying aye, contraminded no. It is agreed to. The President.

MR. O. P. PARRY.—Mr President, on page 319, article 24, at the end of (b) it requires that "No hair, fiber or similar material of any kind or in any quantity shall be added to the mortar." I have found in actual practice that hair absolutely should be added to the first coat; and in talking with several practical Mr. Parry.

Mr. Parry. men I understand that this is also their experience. I should like to know what is the reason for omitting the hair in the first coat.

Mr. Chapman. MR. CLOYD M. CHAPMAN.—Mr. President, that particular sentence is the pivot on which paragraph (b) of the specification turns. This paragraph is for metal lath. In order to fill the entire space back of the lath the mortar must be pressed through firmly and solidly. If the mortar contains hair or fiber the plasterer can make the mortar stick without filling the space back of the lath. The elimination of the fiber compels the filling of this space and while the contractor will object and say it cannot be done, it can be and is being done successfully.

Mr. Parry. MR. PARRY.—I would not use fiber. I do not think it is the common practice of the architects to use fiber in exterior work. It is possible to use hair for this purpose. Of course, you are not going to lump it up any more than you are going to poorly slack your lime or mix your mortar. If you have it well distributed in the mortar it will go through the lath, and will tend to hold the plaster, because it will give additional strength to that key. I do not think that the hair should be omitted.

The President. PRESIDENT HUMPHREY.—It seems to the chair that this is primarily a Portland cement stucco, that is two-thirds Portland cement and one-third lime; and I surely do not see how the hair is going to help its holding power.

Mr. Parry. MR. PARRY.—For the last ten or twelve years I have been using a proportion of lime which I adopted after consultation with one of the best plasterers in the East, Thomas Allen of Philadelphia, Pa. The specification that he gave me, and that I have used in many places with good results is as follows:

> "Exterior plaster. Provide heavy grade metal lath, rough cast exterior building where shown, including dormers, etc,; rough cast to be two-coat work; to consist of 1 part cement, 2 parts clean, sharp sand, well mixed with lime paste containing abundance of hair; one shovelful of paste to hod of mortar. Second coat to be as above without the hair, accurately matching present work."

That specification answers the question of Mr. Ferguson as to the amount of lime in the first coat. My own experience has been that if you do not use lime you get too rich a first coat and one that will crack, and if it cracks you are defeating the very

object of that first coat. Therefore, I always use lime. I do not think you must use hydrated lime; I do not always use a prepared hydrated lime, very seldom, in fact. Mr. Parry.

MR. CHAPMAN.—I want to emphasize that in the black plastering in which the first coat is applied from the outside, it must adhere of its own plasticity or with the aid of hair, and we specified the use of hair or fiber. Now that does not add any strength to the mortar after it has set. The hair as now produced is stripped from the hide with the use of an acid and if that acid is not thoroughly washed out of the hair that is used for plaster, the chemical action due to the acid in the hair and of the alkali in the mortar, will destroy the hair in a very short time. But aside from that, the point is to fill this space back of the lath. We do not claim it cannot be filled if there is hair in the mortar, but it must be filled if there is no hair in the mortar. That is the only way it will stay on. That is the essential feature of this specification (b), and to eliminate that provision would destroy the force of this specification with that method. Now the quantity of lime is specified here as not in excess of one-third the volume of the cement. We have taken this matter up with all whose addresses we have been able to get who are applying stucco. We have communicated with many hundreds of men and have obtained their ideas on this subject and a large part of this specification is the result of averaging their opinions. This is not the result of any one man, or half a dozen men, but it is the average of the opinions of several hundred stucco workers. We specify the addition of lime putty of one-third of the volume of the cement. I am safe in saying we have not found three who would recommend any more than that. We have set the limit about as high as any of them wanted to go, and they certainly may use less under the specifications. Mr. Chapman

MR. PARRY.—It is good practice and uniformly specified that the hair shall be well washed. If it is not well washed that is the fault of the material. I do not think for an instant that we should throw up our hands and acknowledge that we cannot get a thing if we specify it. And I know from practical experience in work in different parts of the country, that I can get a good piece of workmanship by using hair. I think if you asked the average contractor to omit the hair he would be horror struck. Mr. Parry.

Mr. Parry. If he said that he would omit it and you stayed away long enough you would find that he got it in. At least that has been my experience. The great trouble we have is that the average plasterer puts the plaster on with a trowel and it is only a coat. Now what he should do is put it on with force, and if he does the hair and mortar will go through and tend to form a key on the back of the lath, whether it be metal or wood. It seems to me the great thing we are absolutely insisting on, back plastering, in a pretty hard thing to do; it increases the cost materially, although in theory it may not. I would like to use wood lath and not back plaster.

Mr. Chapman. MR. CHAPMAN.—Mr. Parry has said that we insist on back plastering. Method (b) is not back plastering. We get the effect of back plastering by compelling the plasterer to push the mortar through against the sheathing boards, thus imbedding the lath. Method (a) is back plastering.

Mr. Parry. MR. PARRY.—How much space do you allow back of it?

Mr. Chapman. MR. CHAPMAN.—About a half inch. If the hair is allowed the plaster can be put on lightly and will not go through the lath but the hair will hold it there; they have not given the bond, they have not filled the space, they have not imbedded the lath on both sides. I am speaking of metal lath. You cannot accomplish that with wood lath and without hair; it will not stay any other way.

Mr. Parry. MR. PARRY.—I think that we ought to say something in the specification about cement coatings, because a great amount of coating is being used all over this country. The specifications provide for waterproofing in the plaster; I think it is very pertinent to make provision for waterproofing on the plaster.

Mr. Wilson. MR. WILSON.—As a matter of fact, these coatings can be put on reinforced concrete surfaces just as well as on stucco. Why should they be included as a stucco specification?

Mr. Parry. MR. PARRY.—Simply because you have a requirement to prevent rusting of the lath. I believe if you have cement coating on your plaster you will have positively less rusting of your lath.

Mr. Chapman. MR. CHAPMAN.—To my mind the most effective answer is that it is not a part of the plasterer's work. The plasterer would not include that in his work. The painter may do whatever is

required under the painting specifications. This is part of the work of this committee. Mr. Chapman.

PRESIDENT HUMPHREY.—I have no doubt then Mr. Parry's suggestion will be considered in that connection. The President.

MR. T. H. SKINNER.—I notice on page 319 of the specifications that sections (a) and (b) both contain a very small word with a big meaning, "*if*" lime putty be added. What is the recommendation of the committee with regard to this addition of putty? Some say, "if the cement mortar works hard, I add lime putty to a certain extent;" others say, "I can put cement stucco on and it does not work hard and it does not matter and I do not want lime putty;" and so it goes. What is the consensus of opinion of these several hundred contractors who have been consulted as to the need of lime putty? Cannot we get a verdict —and at least make a recommendation, one way or the other? Mr. Skinner.

MR. CHAPMAN.—The opinion is just as diametrically opposed as day is to night. One will not use lime putty in the first coat, says it is the worst thing you can do, and another says that 25 per cent of lime putty ought to be used. We do not contend that these specifications are for the amateur. We do think they are so drawn that they will be a good guide in stucco work and produce good work. To put in the specification either that a certain amount of lime putty is to be used, or that no lime putty is to be used, would lead to confusion; some contractors would say the provision was all right and some that it was no good, depending on their point of view. We desire a definite expression of opinion before the requirement is to be included in the specification. Mr. Chapman.

MR. SKINNER.—That leaves the whole thing absolutely open, just as it has been; leaves it entirely up to the man who is writing the specification. It does not give him any recommendation. Now I supposed the object of this investigation, as much as anything, was to collect all the evidence, not available in any particular locality, sort it, sift it and find out what is the best practice. This to my mind is not a "standard specification" as it stands. Now if you are not prepared to make a recommendation I do not see the use of making a specification at all. It says, "If you do it this way, do it this way; if you do the other way, do it the other way." Now, as an architect, all I have to go by on such Mr. Skinner.

Mr. Skinner. matters when writing my specifications is the best practice as I get it from builders and owners from all over the country. On this point opinions are as diverse as the different sections of the country and as the different men, but a technical body like this ought after a while to be able to tell which is right. Then architects can specify good practice and insist on it.

Mr. Chapman. MR. CHAPMAN.—We know from the evidence that has been presented that perfectly good, satisfactory work, can be made without any lime putty in the first coat. Some very good contractors do not use it, others use it considerably. We might present such evidence as we have, that is, give the names and addresses of several scores of contractors, and their individual opinions and average them. This specification is the result of such a canvass, and as it stands has been mailed to several hundred contractors for criticism; and while a great many opinions have been expressed as to these percentages, practically all of them, 95 per cent of them, would come within the limits allowed in these specifications, that are almost as great as the variation in practice in the country. The committee was asked a year ago to develop a specification for stucco on wood lath. In order to do that it endeavored to find as many contractors as it could who were proficient in the application of stucco on wood lath who believed in doing that work. It wrote a circular letter to over 300 members of the Institute and others asking information chiefly as to names and addresses of contractors who were recognized as proficient in applying stucco on wood lath. As the result of that correspondence about 55 names of contractors who were said by the correspondents to be up in that line of work were obtained. Those 55 were written to and were sent follow-up letters, and asked specific questions as to the details of applying stucco on wood lath. About 17 or 18 replies were received and these indicated that less than half of those men were in favor of using wood lath for stucco. However, some of those who did advocate wood lath were recognized as experienced, their work had been thoroughly satisfactory, and there was no reason to believe that properly used wood lath was not a satisfactory medium on which to apply stucco. So that while the recommendations submitted are based on the practice of a comparatively few contractors, they are those whose work is looked upon

as first-class. The committee made inquiries as to five different types of construction, four of which were based on the use of two layers of lath. The replies seemed to be divided into those that recommend several layers of lath or counterlath, as they call it, and the single layer of lath. When a single layer of lath is used there seems to be little variation in the method; simply one layer of furring strips laid horizontally with a sufficient lap between them to allow keys. But when they are placed on two layers there is a variety of methods used. In the first place, they back plaster. The two layers are laid diagonally on studding or furring strips, depending on whether or not sheathing boards are used. Where sheathing boards are not used the lath are nailed directly to the studding, both at an angle, so that they make lap work, and the space between the lath is much wider than in the case of the single layer laid horizontally; that is, the distance is an inch or more between the lath; so that there are spaces the width of the lath apart one inch square, in which the mortar may be placed. Now, of these five methods, the first was counterlath back plastered on studs, the second counterlath back plastered on furring strips (placed horizontally on the studs), that is, the vertical studs were placed 12 in. to 16 in. apart and on these were furring strips 2 in. by $\frac{3}{8}$ in. horizontally 12 in. apart; on the furring strips were placed 2-in. lath, 1 in. apart, diagonally, so that a 4-ft. lath spanned three spaces between those furring strips, 12-in. centers. Then the second layer of lath was nailed on top of that in the opposite direction. The third was with sheathing boards; the method was to put on the sheathing boards, then a layer of tar paper laid on vertically, and on the tar paper a furring strip of common lath, with the paper as laid, and two layers of lath, diagonal to each other, spaced one inch apart. And the last method was virtually the same, except that the furring strips were $\frac{7}{8}$ in. thick, 2 in. wide, instead of the common lath. Those are the four methods of counterlathing. The fifth method was the use of a single layer of lath directly on furring strips, nailed over the sheathing paper on sheathing boards. Now those methods were submitted and the results indicated that the profession seemed to be about equally divided between counterlathing or the double layer of lath, and the single layer of lath; and those that were in favor of the double layer of lath were, I think, 5 out of 8 or 9

Mr. Chapman.

Mr. Chapman. in favor of one particular form of double layer, which was the last one I mentioned. Now, between that method and the single layer of lath they were about equally divided. So we have drawn up a specification based on our metal lath specification, only making such alterations as apply to the kind of lath used, in which we give these two alternate methods, the double layer and single layer. That makes a rather simple change in the present specifications on metal lath, by making only such modifications as apply to stucco on wood lath and the method of applying it.

Mr. Boyer. MR. BOYER.—What is a narrow lath?

Mr. Chapman. MR. CHAPMAN.—Where there is more than one size we prefer the narrowest as giving more bond. We want to be definite; where there is more than one lath on the market we choose the narrow one.

Mr. Boyer. MR. BOYER.—Is there any reference made as to the quality of wood in the lath?

Mr. Chapman. MR. CHAPMAN.—None other than that it shall be standard first quality, no kind of wood specified, because that varies. The cheapest wood available in any particular market is used for lath —any scrap that is big enough to cut lath out of. To specify the quality would be to specify a different quality for every state in the Union and some counties.

The President. PRESIDENT HUMPHREY.—Those in favor of the motion that the specification for stucco on metal lath, with amendments, be approved and sent out to letter ballot say, aye; contraminded, no; the motion is agreed to.

Mr. Chapman. MR. CHAPMAN.—I think we will get more discussion of the wood lath specifications if it goes out as a proposed standard specification.

The President. PRESIDENT HUMPHREY.—The specification could not go to letter ballot, because it must be distributed to the members 30 days in advance of the annual meeting; it would be a mistake, however, not to print the specification, because by so doing we will secure discussion at the next convention; those in favor of printing it as a proposed specification only will signify by saying aye; opposed no. It is so ordered.

THE ARTISTIC TREATMENT OF CONCRETE STRUCTURES.

By Oliver Randolph Parry.*

While much of lasting benefit should result from this well attended and diversified gathering, yet an analysis of these proceedings reveals the fact that only a few gentlemen representing the profession of which the speaker is a member are or have been present during our deliberations. This does not seem exactly as it should be, either for the good of the architectural profession or for the good of concrete as a building material and must suggest to our officers and members that something is lacking to excite a real interest in concrete construction which we, as a body, advocate. Can it be that the lack of a proper exploiting of examples of artistic treatment in our magazines, and insufficient papers upon this subject in our Proceedings are partly the cause of such disinterestedness? The speaker thinks this is the case to a great extent.

Now, gentlemen, we are all perfectly cognizant of the great ability of the officers of this organization; we know what they have accomplished in the past, are accomplishing now and can accomplish in the future, therefore, it seems reasonable to believe that the lack of attendance on the part of the architectural profession rests largely with that profession at large. This is to be regretted, since the foundation source of all work should be the incentive for, and contain instruction to make possible, the very best artistic design and workmanship. The majority of you gentlemen, the speaker presumes, are structuralists and, therefore, naturally look to the architect to give you that which is to be followed in the design and treatment of the work to be executed. Now if the architects do not devote thought and study to concrete construction from the artistic point of view there must be some cause or causes which it would be well to ascertain immediately.

* Architect, Philadelphia, Pa.

Can it be a fear of lack of possibilities in concrete as a material susceptible to artistic treatment, or possibly a disinclination to develop the possibilities of this material in general practice outside of the usual commercial building? We can hardly believe it can be the latter, because every new structural material introduced into the building world has been taken up and is being employed, alone or in combination with other materials, to produce artistic results. How much more possible is it to procure the most artistic treatment with concrete? Those present who have worked along art lines in concrete construction, realize the great possibilities that this material holds, and are, no doubt, like the speaker, anxiously awaiting development along this line which will evidently put concrete in its proper place as a leading material in arts and crafts.

The speaker does not believe, as a member of the architectural profession, that there is a single material used in the building world as acceptable and adaptable to artistic treatment as this same concrete, not alone perhaps as plain commercial concrete but in combination with cement, white or yellow sand, and colored aggregate susceptible to treatment with the bush hammer, etc., as well as in combination with other materials such as brick, stone, tile, etc., and in treatment with various color and tone cement coatings now so generally procurable in the open market. In fact, there is no end to the variety of treatment one can obtain with intelligent study and ingenuity; and in addition to reproducing every kind of "art stone" from Indiana limestone to granite, it is also possible to procure hard wood effects, which, when treated as a finished article, so closely imitate oak, chestnut, etc., that the only way to tell the difference is through the touch.

Now, gentlemen, it would appear to the speaker as though we should devote more time and attention to the artistic features of concrete work, and that a much greater proportion of the papers read before the Institute should be on this subject and our technical publications contain in every issue numerous examples of executed artistic concrete work.

In addition it cannot be too strongly advocated that a yearly publication be issued by the American Concrete Institute along the lines of the *Architectural Record* or some similar publication, with illustrations of the better and more artistic class of build-

ings erected in concrete during the preceding year. The distribution of this book should be to the architects' offices throughout the country either by subscription or, if need be, in some cases, complimentary. Every designer, every man who creates the beautiful, should have a copy of it; and the speaker believes if the work that has been done is shown, the possibilities of concrete will be so generally recognized that from year to year the increase in extent of use and beauty of designs will continue until the less permanent building materials give place to concrete.

From the Institute's point of view, the more art it develops in concrete construction the greater the opportunity for increased membership from the architectural and building fields, which the speaker thinks would not be a disadvantage. The speaker urges that our President and each member of the Institute seriously considers this, and that it be taken up by the Board and word be sent broadcast throughout the entire country that we stand for artistic treatment in all structural work where concrete is a component material and that this is one of the most advantageous features in the selection of concrete as a building material.

Let us see that the architects become interested in concrete. It is absurd to expect the majority of you gentlemen who are busy with large problems along commercial lines and in other directions, to devote your time and thought to suggesting what can be done in the way of texture and color treatment for the architects' instruction. It seems absurd, because the architect should design and originate. He knows what best follows out his own creation and how to secure his effects, and if he asks the "Structuralist" to do this for him then he is negligent and not fulfilling his entire duty.

In closing the speaker wants to thank you for this opportunity to say what has been long in his mind; and while it might have lain dormant a little longer, this is perhaps as opportune a time as any for an expression which may stir our exhibitors at the cement show to do even better next year. He does trust that much greater importance will be attached to the treatment of concrete structures and work, that an educational campaign will be pushed throughout the country in this connection and that we will enroll more members of his profession in the American Concrete Institute.

DISCUSSION.

Mr. Skinner.

MR. T. H. SKINNER.—I am an architect and I can hardly be silent, in view of what Mr. Parry has said in criticism of the profession, when I know that the subject of artistic design in concrete is in the thoughts of the majority of the leaders of our profession. I say this because I have been in their offices a great many times in the last twenty years, and know that the leading architects in New York, Boston and Chicago are working on the problem. Concrete, *i. e.*, modern concrete, is practically a new material. It is enough to admit that architects, who have been trained in the architectural language of the Greeks and Romans, and have thought for years in terms of stone and especially of cut stone in all its forms and with all its limitations, have not attempted until recently to think monolithically, and their concrete designs have been imitations of the old styles of architecture—though as I understand it, the manufacturers of cement do not decry the architects for this, but for not making a larger use of it in expensive and artistic structures.

Now the very defects that the American Concrete Institute is working to eliminate from concrete, because we know there are defects, are those which the architects have found. Some are bound up in the chemical composition of cement; some are connected with the manipulation of cement. As examples of the first, I would mention—defects like hair cracking, or map cracking, which spoil the texture of the surface; of the second, the coating of cement on picked or selected aggregate which spoils its beauty, giving a dull, dead appearance, and the fact that no two batches of concrete dry out to exactly the same color. These are the things which have made the architect hesitate to use concrete in work which is designed to stand artistically, and upon which he builds his reputation. These are defects for the manufacturer or contractor and not for the architect to eliminate.

The American Concrete Institute is solving these problems through its technical investigations which are made by practical men; and I believe that when it has solved them, when it has

found a method of construction by which the surface can be cleaned, or kept clean and the quality and beauty of the different aggregate brought out, architects will not quarrel with concrete as a building material. The Committee on Treatment of Concrete Surfaces of which Mr. Wason is Chairman, is going to make a report; it is doing a great work and when that work is completed and we can give architects what they want, none will be able to say with any shadow of justification that architects are not doing their duty by concrete. I know that leading men in the profession are studying it as they have opportunity—some are making helpful suggestions and all are only waiting for the solution of those problems on which we are working here, to take hold of it in a big, broad way. Mr. Skinner.

REPORT OF COMMITTEE ON BUILDING BLOCKS AND CEMENT PRODUCTS.

Your Committee believes that the manufacture of cement products constitutes one of the most important uses of cement. The apparent ease with which this manufacture may be accomplished has led many untrained persons to engage in the business without an understanding of the fundamental principles necessary to success in using cement in any class of construction.

To criticize building departments and boards of fire underwriters for their failure to recognize the efficiency of cement products is idle until the manufacturers of such products shall recognize a uniform standard. No higher duty devolves upon the members of the American Concrete Institute than to formulate, adopt, promote and insist upon the unvarying maintenance of standards which shall bring various cement products into universal recognition.

To aid in accomplishing this desirable purpose your Committee submits for your consideration, recommended practice for the following cement products:

(1) Plain Concrete Pipe and Drain Tile.
(2) Concrete Architectural Stone, Building Block and Brick.
(3) Concrete Fence Posts.

Your Committee also submits for your consideration Standard Building Regulations for the use of Concrete Architectural Stone, Building Block and Brick.

Respectfully submitted,

C. K. Arp, *Chairman.*
E. S. Hanson,
J. K. Harridge,
Robert F. Havlik,
H. H. Musselman.

AMERICAN CONCRETE INSTITUTE

Founded 1905 and Incorporated 1906, as

NATIONAL ASSOCIATION OF CEMENT USERS

Charter Amended July 2, 1913.

PHILADELPHIA, PA.

RECOMMENDED PRACTICE FOR PLAIN CONCRETE PIPE AND DRAIN TILE.

This recommended practice is intended to cover general requirements for the manufacture of plain concrete pipe and drain tile; drain tile being used for drains, culverts, storm water sewers and to carry surface water and ground water only; pipe to be used for all purposes where drain tile are suitable, and pipe only to be used for carrying water containing sewage, acids, alkali or factory waste.

MATERIALS.

1. The cement shall meet the requirements of the Standard Specifications for Portland Cement of the American Society for Testing Materials revised to date, and adopted by this Institute (Standard No. 1).

2. Fine aggregate shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse and passing when dry a screen having 4 meshes per lin. in.; shall preferably be of siliceous material, clean, coarse, free from dust, soft particles, loam, vegetable or other deleterious matter; not more than 20 per cent shall pass a sieve having 50 meshes per lin. in., and not more than 6 per cent shall pass a sieve having 100 meshes per lin. in. Fine aggregate shall be of such a quality that mortar composed of 1 part Portland cement and 3 parts fine aggregate by weight when made into briquettes will show a tensile strength

equal to, or greater than, the strength of 1:3 mortar of the same consistency made with the same cement and standard Ottawa sand. In no case shall fine aggregate containing frost or lumps of frozen material be used. In no case shall fine aggregate contain more than 3 per cent by weight of clay, loam or other organic or soluble matter as determined by washing according to the following method:

A sample weighing from 100 to 200 grams is placed in a percolator $2\frac{1}{2}$ in. to 3 in. in diam., into which water is supplied at the bottom through a $\frac{1}{4}$ in. round opening from a supply wherein the water surface is elevated 3 ft. above the surface of the water in the percolator, so as to maintain the flow under a head of about 3 ft. The sample is thoroughly washed until the effluent water is clear. If the weight of the material so washed from the sample exceeds 3 per cent of the dry weight of the original sample, the material shall not be used for concrete pipe or tile.

3. Coarse aggregate shall consist of inert material, as gravel or crushed stone, graded in size, retained on a screen having 40 meshes per lin. in.; shall be clean, hard and durable, free from dust, vegetable or other deleterious matter, and shall contain no soft, flat, or elongated particles. In no case shall coarse aggregate containing frost or lumps of frozen material be used. Maximum size of coarse aggregate shall be no greater than one half the wall thickness of the pipe or drain tile.

4. Natural mixed aggregate shall not be used as they come from the deposit, but shall be screened over a $\frac{1}{4}$ in. screen and remixed to agree with the proportions as specified. The following exception to the rule may be noted, although in general best results will be obtained by screening out the material coarser than $\frac{1}{4}$ in. and reproportioning.

5. In the manufacture of pipe or drain tile in which it is found practicable to use aggregates having the maximum size of $\frac{1}{2}$ in., natural mixed aggregate in the proportions hereinafter specified, may be used by screening through a $\frac{1}{2}$ in. screen, provided the grading be such that not less than 50 per cent by weight is retained on a standard No. 10 sieve and that the grading as a whole closely agrees with the gradation shown below, which is

recommended as approaching the most practicable mixture of the different sizes.

SIEVE.	PER CENT PASSING.
½ in.	100
¼ in.	70
No. 10	50
No. 20	40
No. 30	30
No. 40	20

6. In making pipe or drain tile by ordinary processes, using machines equipped with a revolving packer head, or with tampers and revolving core to form the shell, it will be found practicable to use aggregate having a maximum size of particles of ¼ in. for all sizes of pipe and tile up to 12 in. For 12 in. and larger sizes, it will be found practicable to use aggregate having a maximum size of ½ in. Deficiency in fine material in the aggregate causes difficulty in the manufacturing process; loss of pipe or tile when removed from the casing, rough surfaces, stone pockets and thin holes through which water spurts when internal water pressure tests are applied. Deficiency in fine material within rather wide limits does not decrease the strength of the finished product. Excess of fine material causes low strength in finished pipe or tile and with ordinary mixtures tends to produce pipe or tile which will show seepage under internal pressure tests. The tendency to use an excess of fine material in the aggregate is to be guarded against, because unless pipe or tile is tested the manufacturers may be deceived as to the quality of the product he is making, owing to the smooth and apparently workmanlike appearance of pipe or tile in which aggregate containing an excess of fine material has been used.

7. Water shall be clean, free from oil, acid, strong alkali or vegetable matter. An automatic measuring device should be used to measure the amount of water used in each batch of concrete, and after the desired consistency has been determined, this amount should be used in each batch until working conditions demand a change.

PROPORTIONS.

8. For drain tile up to and including 10 in. in diam., concrete should be mixed in the proportion of 1 bag of Portland

cement to not more than 3 cu. ft. of fine aggregate. For the manufacture of drain tile over 10 in. in diam., in which coarse aggregate having the maximum size of particles of ½ in. or more is used, concrete should be mixed in the proportion of 1 bag of Portland cement to not more than 5 cu. ft. of fine and coarse aggregate measured separately, and in no case shall the mixture contain more than 3 cu. ft. of fine aggregate to each bag of cement. If well graded, natural mixed aggregates up to ½ in. in size are used, as previously noted, a mixture of 1 bag of Portland cement to not more than 3 cu. ft. of mixed aggregate shall be used.

9. For the manufacture of pipe up to and including 10 in. in diam., concrete shall be mixed in the proportion of 1 bag of Portland cement to not more than 4 cu. ft. of fine and coarse aggregate measured separately. In no case shall the mixture contain more than 2½ cu. ft. of fine aggregate to each bag of cement.

MIXING.

10. A bag of Portland cement (94 lb. net), shall be considered 1 cu. ft. The method of measuring the materials for the concrete shall be one which will insure separate and uniform proportions of each of the materials at all times. When cement is used in bulk, it shall be accurately measured in such manner as will insure that the measured amount used as the equivalent of 1 bag, shall be 94 lb.

11. Concreting materials shall be mixed to the desired consistency in a batch mixer of approved type, and the mixing shall continue for at least one minute after all materials, including water, are in the mixer.

12. Retempering of mortar or concrete that has partially hardened, that is, remixing with additional materials, or with water, shall not be permitted.

13. Concrete shall be mixed as wet as can be used and allow the immediate removal of the outer casing from the pipe or drain tile. As an indication of the required consistency the pipe or tile should show on the outer surface web-like markings or water marks indicating free moisture after the removal of the outer casing. Interior surfaces of the pipe or drain tile should show trowel marks caused by free water coming to the surface under

the trowel-like action of the revolving packer head or core in case such is used.

14. Pipe or drain tile should be made in such a manner as to insure a dense and uniformly compacted product with smooth ends and inner surfaces. Pipe and drain tile shall be formed so as to prevent laminations or planes of weakness. Each pipe or drain tile shall be of a cylindrical section, the size being designated by the interior diameter. The thickness of the pipe or drain tile shall be practically uniform throughout and shall be not less than $\frac{1}{10}$ the diameter with a minimum of $\frac{1}{2}$ in. for drain tile and $\frac{3}{4}$ in. for pipe. The diameter shall not vary more than 3 per cent from that specified.

WINTER WORK.

15. No pipe or drain tile shall be made when the temperature of the atmosphere surrounding the machine is lower than 50° F. Aggregate and water shall be heated when the temperature of either is lower than 50° F.

CURING.

16. Within 60 min. after removing the outer casing from the pipe or drain tile, they shall be placed in a curing chamber where the temperature is not lower than 50° F. and protected from drafts of air and from all exposure which will tend to cause evaporation of moisture from the concrete. Within 12 hr. after removing the pipe or drain tile from the machine, the temperature of the curing chamber shall be raised to between 100° and 130° F., and an atmosphere saturated with water vapor shall be maintained by introducing water vapor from the boiler into the curing chamber. This water vapor shall be introduced through a perforated pipe laid with perforations down in a trough of water in the floor of the curing chamber.

(*a*) When the outside temperature during the day time does not fall below 50° F., the pipe or drain tile shall be steam cured as described above, for not less than 48 hr., after which they may be removed from the curing chamber and piled in the yard. They shall then be sprinkled not less than 3 times daily for 7 days.

They may be shipped after having laid in the yard not less than 14 days.

(*b*) When the temperature of the outside atmosphere falls below 50° F. during the daytime, the pipe or drain tile shall be steam cured for not less than 96 hr., after which they may be piled in the yard. They need not receive any further treatment, but shall remain in the yard for not less than 14 days.

17. In the steam curing process, two requirements must be observed, as neglect of these sometimes causes improper curing. First: The steam curing chamber must be so tight as to prevent circulation of air and the consequent existence of a heated atmosphere not thoroughly saturated with water vapor, which would result in evaporation of water from the pipe walls. Second: Steam should not be allowed to enter the curing chamber under pressure in such a manner as to strike the green pipe or drain tile. The effect of this is to heat them quickly and cause the evaporation of water from the interior of the pipe or the tile walls and the destruction of the product.

18. When it is found impracticable to introduce water vapor into the curing chamber, the pipe or drain tile shall be handled in the same manner as previously described for steam curing (paragraph 16), until they have become sufficiently hard so that the application of water does not injure them. The pipe or drain tile shall then be kept constantly wet on the surface by sprinkling with water for not less than 7 days for case (*a*), and 14 days for case (*b*), and the temperature shall be maintained at not less than 70° F. in the curing chamber. After removal from the curing chamber, the pipe or drain tile shall be treated as already described for steam curing (paragraph 16), except that the period of storage in the yard shall not be less than 14 days.

19. In cases where it is desired to use a combination of steam and water curing, the pipe or drain tile shall be cured in the steam chamber under conditions described above for steam curing (paragraph 16), until such time as they are sufficiently hardened to permit piling one on top of another. They may then be removed to a sprinkling chamber where they will be at all times protected from drafts of air. Here they shall be kept constantly wet on the surface by sprinkling for a period of not less than 2 days for case (*a*)

and not less than 7 days for case (*b*). The temperature in the sprinkling chamber shall be maintained at not less than 70° F. for the periods mentioned. After removal from the sprinkling chamber the pipe or tile shall be treated in the manner described above for steam curing (paragraph 16), except that the period of storage in the yard shall not be less than 21 days.

TESTS.

20. Indications of good quality in pipe and drain tile are:

First: High supporting strength.
Second: Low percentage of absorption.

21. In making strength tests of drain tile or pipe, the methods proposed by Committee on Drain Tile of the American Society for Testing Materials should be followed, and the specimens should have minimum average supporting strength in accordance with the following table:

DIAMETER (IN.).	LB. PER LINEAR FOOT.
8	1,000
10	1,050
12	1,150
14	1,200
16	1,500
18	1,700
20	2,100
22	2,300
24	2,500

22. Pipe or drain tile which shows a small percentage of absorption are to be preferred in every respect to those that show high absorption. In making examination to determine the absorption, it is necessary to dry pipe or tile at a temperature of 212° F., until they show no further loss in weight. Pipe or drain tile will absorb their full capacity of water within 24 hr. after immersion. Tests have shown that high strength and low absorption go hand in hand.

AMERICAN CONCRETE INSTITUTE

Founded 1905 and Incorporated 1906, as
NATIONAL ASSOCIATION OF CEMENT USERS
Charter Amended July 2, 1913.

PHILADELPHIA, PA.

RECOMMENDED PRACTICE FOR CONCRETE ARCHITECTURAL STONE, BUILDING BLOCK AND BRICK.

This recommended practice is intended to cover general requirements for the manufacture and testing of concrete architectural stone, building block and brick.

MATERIALS.

1. The cement shall meet the requirements of the Standard Specifications for Portland Cement of the American Society for Testing Materials, revised to date and adopted by this Institute (Standard No. 1).

2. Fine aggregate shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse and passing when dry a screen having 4 meshes per lin. in.; shall preferably be of siliceous material, clean, coarse, free from dust, soft particles, loam, vegetable or other deleterious matter; not more than 20 per cent shall pass a sieve having 50 meshes per lin. in., and not more than 6 per cent shall pass a sieve having 100 meshes per lin. in. Fine aggregate shall be of such quality that mortar composed of 1 part Portland cement and 3 parts fine aggregate by weight when made into briquettes, will show a tensile strength equal to, or greater than the strength of 1:3 mortar of the same consistency made with the same cement and standard Ottawa sand. In no case shall fine aggregate containing frost or lumps of frozen material be used. In no case shall fine aggregate contain more than 3 per cent by weight of clay, loam, or other

organic or soluable matter as determined by washing according to the following method:

A sample weighing from 100 to 200 grams is placed in a percolator $2\frac{1}{2}$ in. in diam., into which water is supplied at the bottom through a $\frac{1}{4}$ in. round opening from a supply wherein the water surface is elevated 3 ft. above the surface of the water in the percolator, so as to maintain the flow under a head of about 3 ft. The sample is thoroughly washed until the effluent water is clear. If the weight of the material so washed from the sample exceeds 3 per cent of the dry weight of the original sample, the material shall not be used for architectural stone, building block or brick.

3. Coarse aggregate shall consist of inert material, as gravel or crushed stone, graded in size, retained on a screen having 4 meshes per lin. in.; shall be clean, hard and durable, free from dust, vegetable or other deleterious matter, and shall contain no soft, flat or elongated particles. In no case shall coarse aggregate containing frost or lumps of frozen material be used. Coarse aggregate for architectural stone or building block shall vary in size from $\frac{1}{4}$ in. to 1 in.; for brick from $\frac{1}{4}$ in. to $\frac{1}{2}$ in.

4. Natural mixed aggregates shall not be used as they come from the deposit, but shall be screened over an $\frac{1}{4}$-in. screen and remixed to agree with the proportions as specified.

5. Water shall be clean, free from oil, acid, strong alkali or vegetable matter. An automatic measuring device should be used to measure the amount of water used in each batch of concrete, and after the desired consistency has been determined, this amount should be used in each batch until working conditions demand a change.

PROPORTIONS.

6. For architectural stone without mortar face, concrete should be mixed in the proportion of 1 bag of Portland cement to not more than 2 cu. ft. of fine aggregate and 3 cu. ft. of coarse aggregate. For architectural stone with mortar face, the backing of concrete should be mixed in the proportion of 1 bag of Portland cement to not more than $2\frac{1}{2}$ cu. ft. of fine aggregate and 4 cu. ft. of coarse aggregate; the mortar surface should be mixed

in the proportion of 1 bag of Portland cement to not more than 2 cu. ft. of fine aggregate.

7. For concrete block containing no coarse aggregate, the concrete should be mixed in the proportion of 1 bag of Portland cement to not more than 3 cu. ft. of fine aggregate. For concrete block with or without mortar face, in which coarse aggregate is used, concrete should be mixed in the proportion to 1 bag of Portland cement to not more than $2\frac{1}{2}$ cu. ft. of fine aggregate and 4 cu. ft. of coarse aggregate. Facing for concrete block should be mixed in the proportion of 1 bag of Portland cement to not more than 2 cu. ft. of fine aggregate.

8. For brick in which no coarse aggregate is used, concrete should be mixed in the proportion of 1 bag of Portland cement to not more than 3 cu. ft. of fine aggregate. For brick in which coarse aggregate is used, concrete should be mixed in the proportion of 1 bag of Portland cement to not more than 2 cu. ft. of fine aggregate and 3 cu. ft. of coarse aggregate.

9. A bag of Portland cement (94 lb. net) shall be considered 1 cu. ft. The method of measuring the materials for the concrete shall be one which will insure separate and uniform proportions of each of the materials at all times. When cement is used in bulk, it shall be accurately measured in such manner as will insure that the measured amount used as the equivalent of 1 bag, shall be 94 lb.

10. Concreting materials shall be mixed to the desired consistency in a batch mixer of approved type, and the mixing shall continue for at least one minute after all the materials, including water, are in the mixer.

11. Retempering of mortar or concrete that has partially hardened, that is, remixing with additional materials or with water, shall not be permitted.

12. For architectural stone, the concrete should be mixed wet enough so that water will freely flush to the surface with slight tamping.

13. For building block made by hand or power tamping, the concrete should be mixed as wet as practicable to use in the ordinary make of block machine and allow immediate removal of the finished block from the mold. For concrete block made under pressure, the concrete should be mixed wet enough that a slight

excess of water will be ejected from the block when pressure is applied. For concrete block made by the wet process, the concrete should be wet enough to immediately fill all parts of the mold without tamping, but not wet enough to cause the mortar to separate from the coarse aggregate.

14. For brick, the concrete should be mixed as wet as possible to use in the ordinary machines in which brick are made by hand or power tamping, or by the application of pressure. Sufficient water should always be used to slightly flush to the surface under tamping or pressure.

WINTER WORK.

15. No architectural stone, building block or brick should be made when the temperature of the atmosphere surrounding the machine or mold is lower than 50° F. Aggregate and water should be heated when the temperature of either is lower than 50° F.

CURING.

16. Within 60 min. after completing the manufacture of architectural stone, building block or brick, they shall be placed in a curing chamber where the temperature is not lower than 50° F., and protected from drafts of air and from all exposure which will tend to cause evaporation of moisture from the concrete. Within 12 hr. after removing architectural stone, building block or brick from the place of manufacture, the temperature in the curing chamber should be raised to between 100° and 130° F., and an atmosphere saturated with water vapor maintained by introducing water vapor from a boiler into the curing chamber. This water vapor should be introduced through a perforated pipe laid with perforations down in a trough of water in the floor of the curing chamber.

(*a*) When the outside temperature during the daytime does not fall below 50° F., architectural stone, building block or brick shall be steam cured, as described above, for not less than 48 hr., after which they may be removed from the curing chamber and piled in the yard. They shall then be sprinkled not less than 3 times daily for 7 days. They may be used after having laid in the yard not less than 14 days.

(*b*) When the temperature during the daytime does not fall below 50° F., architectural stone, building block or brick shall be steam cured for not less than 96 hr., after which they may be piled in the yard. They need not receive any further treatment, but shall remain in the yard for not less than 14 days.

17. In the steam curing process, two requirements must be observed, as neglect of these sometimes causes improper curing. First: The steam curing chamber must be so tight as to prevent circulation of air and the consequent existence of a heated atmosphere not thoroughly saturated with water vapor, which would result in evaporation of water from architectural stone, building block or brick. Second: Steam should not be allowed to enter the curing chamber under pressure in such a manner as to strike against the green architectural stone, building block or brick. The effect of this is to heat them quickly and cause evaporation of water from the product, resulting in ultimate destruction.

18. When it is found impracticable to introduce water vapor into the curing chamber, architectural stone, building block and brick, shall be handled in the same manner as previously described for steam curing (paragraph 16), until they have become sufficiently hard so that the application of water does not injure the surface. Architectural stone, building block or brick shall then be kept constantly wet on the surface by sprinkling with water for not less than 7 days for case (*a*), and 14 days for case (*b*), and the temperature shall be maintained at not less than 70° F. in the curing chamber. After removal from the curing chamber, architectural stone, building block or brick should be treated as already described for steam curing (paragraph 16); that is, the period of storage in the yard shall not be less than 14 days.

REINFORCEMENT.

19. Architectural stone, subjected to cross bending shall be reinforced by means of rods placed about $1\frac{1}{2}$ in. from the tension surface and the total section area for the reinforcement shall be not less than 0.8 per cent of the cross-sectional area of the concrete in the member reinforced. When any dimension exceeds 8 times the least dimension of any member, such member shall be reinforced to insure safety in handling.

FINISHING.

20. Architectural stone, building block or brick may have exposed surfaces treated by any of the various methods proposed by the American Concrete Institute in specifications or recommendations for treatment of concrete surfaces. All surfaces and arrises must be true and without imperfection. All large and heavy stones shall be provided with metal bonds for the purpose of tying to the masonry backing.

TESTS.

21. Architectural stone, building block and brick not usually being subjected to tensile stresses, their testing is ordinarily limited to compression and absorption.

22. Properly made architectural stone, building block or brick should—at the age of 28 days—sustain without failure a load of 1,500 lb. per sq. in. of gross area as placed in the wall, making no allowance for hollow space.

23. After being dried to constant weight at a temperature of 212° F., architectural stone, building block or brick 28 days old should not show more than 5 per cent absorption after immersion in water 24 hr.

AMERICAN CONCRETE INSTITUTE

Founded 1905 and Incorporated 1906, as
NATIONAL ASSOCIATION OF CEMENT USERS
Charter Amended July 2, 1913.

PHILADELPHIA, PA.

RECOMMENDED PRACTICE FOR CONCRETE FENCE POSTS.

This recommended practice is intended to cover general requirements for the manufacture of concrete fence posts.

Materials.

1. The cement shall meet the requirements of the Standard Specifications for Portland Cement of the American Society for Testing Materials, revised to date and adopted by this Institute (Standard No. 1).

2. Fine aggregate shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse and passing when dry a screen having 4 meshes per lin. in.; shall preferably be of a siliceous material, clean, coarse, free from dust, soft particles, loam vegetable or other deleterious matter; not more than 20 per cent shall pass a sieve having 50 meshes per lin. in., and not more than 6 per cent shall pass a sieve having 100 meshes per lin. in. Fine aggregate shall be of such a quality that mortar composed of 1 part Portland cement and 3 parts fine aggregate by weight when made into briquettes, will show a tensile strength equal to, or greater than the strength of 1:3 mortar of the same consistency made with the same cement and standard Ottawa sand. In no case shall fine aggregate containing frost or lumps of frozen material be used. In no case shall fine aggregate contain more than 3 per cent by weight of clay, loam, or other organic or soluable matter as determined by washing according to the following method:

A sample weighing from 100 to 200 grams is placed in a

percolator $2\frac{1}{2}$ in. to 3 in. in diam., into which water is supplied at the bottom through a $\frac{1}{4}$ in. round opening from a supply wherein the water surface is elevated 3 ft. above the surface of the water in the percolator, so as to maintain the flow under a head of about 3 ft. The sample is thoroughly washed until the effluent water is clear. If the weight of the material so washed from the sample exceeds 3 per cent of the dry weight of the original sample, the material shall not be used for concrete fence posts.

3. Coarse aggregate shall consist of inert material, as gravel or crushed stone, graded to size, retained on a screen having 4 meshes per lin. in.; shall be clean, hard and durable, free from dust, vegetable or other deleterious matter, and shall contain no soft, flat or elongated particles. In no case shall coarse aggregate containing frost or lumps of frozen material be used. Coarse aggregate for concrete fence posts shall vary in size from $\frac{1}{4}$ to $\frac{3}{4}$ in.

4. Natural mixed aggregate shall not be used as they come from the deposit, but shall be screened over a $\frac{1}{4}$ in. screen and remixed to agree with the proportions as specified.

5. Water shall be clean, free from oil, acid, strong alkali or vegetable matter. An automatic measuring device should be used to measure the amount of water used in each batch of concrete, and after the desired consistency has been determined, this amount should be used in each batch until working conditions demand a change.

6. For concrete fence posts containing no coarse aggregate the concrete should be mixed in the proportion of 1 bag of Portland cement to not more than $2\frac{1}{2}$ cu. ft. of fine aggregate. For concrete fence posts in which coarse aggregate is used, concrete should be mixed in the proportion of 1 bag of Portland cement to not more than 2 cu. ft. of fine aggregate and 3 cu. ft. of coarse aggregate.

7. A bag of Portland cement (94 lb. net) shall be considered 1 cu. ft. The method of measuring the materials for the concrete shall be one which will insure separate and uniform proportions of each of the materials at all times. When cement is used in bulk, it shall be accurately measured in such manner as will insure that the measured amount used as the equivalent of 1 bag, shall be 94 lb.

8. Concreting materials shall be mixed to the desired consistency in a batch mixer of approved type, and the mixing shall continue for at least one minute after all materials, including water, are in the mixer.

9. Retempering of mortar or concrete that has partially hardened, that is, remixing with additional materials or with water, shall not be permitted.

10. For concrete fence posts, the concrete should be mixed wet enough that no tamping will be required, compactness in filling the molds being secured by agitating the concrete either by stirring it or by jarring the mold.

11. No concrete fence posts should be made when the temperature of the atmosphere surrounding the mold is lower than 50° F. Aggregates and water should be heated when the temperature of either is lower than 50° F.

CURING.

12. Within 60 min. after completing the manufacture of concrete fence posts, they shall be placed in a curing chamber where the temperature is not lower than 50° F. and protected from drafts of air and from all exposure which will tend to cause evaporation of moisture from the concrete. Within 12 hr. after removing the concrete fence posts from the place of their manufacture, the temperature in the curing chamber should be raised to between 100° and 130° F. and an atmosphere saturated with water vapor maintained by introducing water vapor from the boiler into the curing chamber. This water vapor should be introduced through a perforated pipe laid with perforations down in a trough of water in the floor of the curing chamber.

(*a*) When the outside temperature during the daytime does not fall below 50° F., concrete fence posts shall be steam cured, as described above, for not less than 48 hr., after which they may be removed from the curing chamber and piled in the yard. They shall then be sprinkled not less than 3 times daily for 7 days. They may be used after having laid in the yard not less than 14 days.

(*b*) When the temperature of the outside atmosphere falls below 50° F. during the daytime, concrete fence posts shall be steam cured for not less than 96 hr. after which they may be

piled in the yard. They need not receive any further treatment, but shall remain in the yard for not less than 14 days.

13. In the steam curing process, two requirements must be observed, as neglect of these sometimes cause improper curing. First: The steam curing chamber must be air tight as to prevent circulation of air and the consequent existence of a heated atmosphere not thoroughly saturated with water vapor which would result in evaporation of water from the concrete fence posts. Second: Steam should not be allowed to enter the curing chamber under pressure in such a manner as to strike the green concrete fence posts. The effect of this is to heat them quickly and cause evaporation of water from the product, resulting in ultimate destruction.

14. When it is found impracticable to introduce water vapor into the curing chamber, concrete fence posts shall be handled in the same manner as previously described for steam curing (paragraph 12), until they have become sufficiently hard so that the application of water does not injure the surface. Concrete fence posts shall then be kept constantly wet on the surface by sprinkling with water for not less than 7 days for case (*a*) and 14 days for case (*b*), and the temperature shall be maintained at not less than 70° F. in the curing chamber. After removal from the curing chamber, concrete fence posts should be treated as already described for steam curing (paragraph 12), that is, the period of storage in the yard shall not be less than 14 days.

REINFORCEMENT.

15. Concrete fence posts of dimensions usually known as "line posts" shall be reinforced by imbedding at each corner of the post, $\frac{3}{4}$ in. from the surface, a $\frac{1}{4}$ in. steel rod, twisted bar or wire.

16. Concrete fence posts of dimensions usually known as "corner posts" shall be reinforced by imbedding at each corner of the post, $\frac{3}{4}$ in. from the surface, a $\frac{9}{16}$ in. steel rod or other reinforcement of equal cross section.

17. Concrete braces for sustaining the position of corner posts shall be reinforced by imbedding at each corner of the brace, $\frac{3}{4}$ in. from the surface, a $\frac{3}{8}$-in. steel rod or other reinforcement of equal cross section.

AMERICAN CONCRETE INSTITUTE

Founded 1905 and Incorporated 1906, as
NATIONAL ASSOCIATION OF CEMENT USERS
Charter Amended July 2, 1913.

PHILADELPHIA, PA.

STANDARD BUILDING REGULATIONS FOR THE USE OF CONCRETE ARCHITECTURAL STONE, BUILDING BLOCK AND BRICK.

I. General.

1. Concrete architectural stone, building block and brick meeting the requirements set forth in Standard Recommended Practice may be used in building construction, subject to the usual form of approval required of other materials of construction by the bureau of building inspection.

2. The height of buildings constructed of such concrete building products shall be limited by the requirements in these regulations.

II. Details of Construction.

3. (*a*) Bearing Walls, 25 ft. span.—The thickness of bearing walls in such buildings as garages, stables, office buildings, hotels, tenements, boarding and lodging houses and residences, shall be as given in the table below, for buildings in which the maximum distance between bearing walls or columns does not exceed 25 ft.

Number of Stories.	Thickness of Wall in Inches.				
	Basement.	First Story.	Second Story.	Third Story.	Fourth Story.
1	10	8	..	..	..
2	12	10	8	..	..
3	12	12	10	8	..
4	16	12	10	10	8

(*b*) Bearing Walls, more than 25 ft. span.—In buildings not covered by the above, the thickness of the bearing walls shall be determined according to the limit of loading specified in paragraph 6. In no case, however, shall any outside bearing wall be less than 8 in. thick.

(*c*) Party Walls.—Hollow space in concrete blocks used in the construction of party walls shall be filled with concrete, placed on the job.

(*d*) Curtain or Partition Walls.—For curtain walls or partition walls, the requirements shall be the same as in the use of hollow tile, terra-cotta or plaster blocks.

4. (*a*) Bonding.—Where the face only is of hollow concrete block, and the backing is of brick, the facing of hollow block must be strongly bonded to the brick, either with headers projecting 4 in. into the brick work, every fourth course being a header course, or with approved ties, no brick backing to be less than 8 in. thick. Where the walls are made entirely of concrete block, but where said block have not the same width as the wall, every fifth course shall extend through the wall, forming a secure bond, when not otherwise sufficiently bonded.

(*b*) Portland cement mortar shall be made in the proportion of 1 part Portland cement, not more than 2 parts sand and shall be used immediately after being mixed.

(*c*) Cement-lime mortar shall be made in the proportion of 1 part Portland cement, not more than 2 parts sand and not more than $\frac{1}{4}$ part hydrated lime or lime putty.

5. Whenever girders or joints rest upon walls so that there is a concentrated load on the block of over 2 tons, the blocks supporting the girder or joints must be made solid for at least 8 in. from the inside face. When such concentrated load exceeds 5 tons, the blocks for at least three courses below, and for a distance extending at least 18 in. each side of each girder shall be made solid for at least 8 in. from the inside face. Whenever walls are decreased in thickness, the top course of the thicker wall shall afford a full solid bearing for the web and walls of the next higher course of block.

6. No wall composed of hollow concrete block when laid up in cement-lime mortar shall be loaded at any point to an excess of 167 lb. per sq. in. equivalent to 12 tons per sq. ft. of the super-

ficial area of such block as used in the wall including the weight of the wall. When the blocks are laid up in Portland cement mortar, this limit of loading may be increased to 200 lb. per sq. in. In buildings where most of the load is carried by pilasters, said pilasters may be made of hollow concrete building block and the air spaces filled with concrete, placed on the job. Such pilasters shall not be loaded to exceed 300 lb. per sq. in. of gross cross-sectional area.

7. Block for use in bearing walls shall show a crushing strength of at least 1,500 lb. per sq. in. of gross cross-sectional area when 28 days old.

8. Concrete building block or bricks may be used for building chimneys and flues, provided that such chimneys and flues shall conform to the requirements for clay-brick flues as to flue-lining and thickness of walls.

CONCRETE POSTS TO FILL THE GAP.

By A. M. Smith.*

While the concrete post cannot be called new, it has not been given as much attention as its importance warrants.

The application of concrete seemed so ridiculously simple that many of its early users, because of insufficient knowledge, found themselves in trouble, thus affording further proof that "a little learning is a dangerous thing." It is necessary when using concrete for any new purpose to subject it to rigorous tests, and this is precisely what was done with other building materials.

No one would think of using steel, iron, brick or even granite without sound advice from experts; yet we have seen concrete used in lieu of these materials with a lack of information as to what might be expected which would be ludicrous if it had not been, in many cases, tragic.

The concrete fence post ceased to be an experiment a good many years ago. Yet there is much more to be said about its construction than could be told in several times the space allotted.

One thing may be said for the early makers of concrete fence posts; as a rule, they made them strong enough, and clumsy enough, and ugly enough, so that doubtless many of even the poorer ones will endure as long as time exists.

The real problem is found not only in the proper mixture to be used, but in the adoption of good general designs, and types for specific service, together with a thorough knowledge of the results to be secured from posts of varying lengths, cross-sections, etc. When speaking of the manufacture of concrete posts, we must at once sub-divide the subject into materials, their cost, selection and preparation; the reinforcing of the concrete, and the best methods to be employed for that purpose, and finally the general question of the ability of the average man to make a good post either commercially or for his individual need.

There is that sense of the fitness of things in most of us, which makes us want to work with clean materials. Therefore, none need to be told to reject dirty sand or dirty gravel. The

* Manager, Ohio Post Mold Company, Toledo, Ohio.

question of mixture is one over which there may be some argument and the best general rule is to use a mixture of 1 part Portland cement, 2 parts sand and 3 parts either gravel or crushed rock. The size of the gravel or crushed rock depends somewhat on the cross dimensions of the post, but it is not good policy, generally speaking, to use larger aggregate than $\frac{3}{4}$ in. and it may be as fine as $\frac{1}{4}$ in.

There are some good makers of concrete fence posts who work by a rule of thumb, just as there are some mighty good cooks who could not tell how they make their most famous dishes.

But one thing is sure, in the making of concrete, the cement is the most important factor of all. It is the chemical action of the mixture of cement, water, sand and gravel that furnishes the real problem, and you must not err on the side of using less cement than is necessary.

The following remarks as to costs are not suggested by the conditions in any given locality, because they may be favorable so far as one ingredient is concerned, and quite unfavorable as regards the others.

One yard of sand or gravel is sufficient for 40 concrete fence posts. One barrel of cement, using a 1 : 4 mixture, will make 24 posts.

One ton of $\frac{1}{4}$-in. iron bars will reinforce 500 posts, allowing three bars to the post.

These factors will make the cost of the ordinary line post about 15 cents per post on an average, taking the country all over. The question of labor is complicated by the appliances at hand and the efficiency of the workmen who use them. Under the best conditions the labor cost on a post will not be less than 3 cents, and should not exceed 5 cents under any conditions.

The question of reinforcement is also a subject upon which there are many and varying opinions. We find in our practice that the $\frac{3}{16}$-in. bar is thoroughly reliable in the majority of cases, and we have no hesitation in recommending it for general purposes. At the same time it cannot be denied that a $\frac{1}{4}$-in. bar would be stronger, and if we are in doubt we use the heavier bar. It is a waste of money to use a bar having a diameter greater than $\frac{1}{4}$ in. The position of the bar in the post is almost of as great importance as the quality of the bar itself. The reinforcement gives to con-

crete the tensile strength that this material lacks. As we all know, concrete resists compressive strains admirably but is weak in tensile resistance. For this reason, the reinforcing bars should be placed at the farthest radii from the center of the mass or neutral axis, and should be so embedded beneath the surface of the concrete that weather conditions will not affect them.

We have been making molds for use by farmers and for fence post dealers for a number of years and these molds have been rather widely distributed throughout the country. There have been but few complaints and these can often be attributed to lack of intelligent work on the part of the users of the molds.

We teach our buyers not to use tamped concrete, and that the slush mixture is better in every way. The operator very quickly learns that he should have a mixture that will pour readily from a pail or scoop, preferably a little too wet, than not wet enough. We try in every way to convince the makers of concrete posts that the aging of this material is a true chemical action which requires more time than the average man would imagine. We explain to them that the posts should not be exposed either to the sun or to dry air currents, so that the water will not be evaporated too quickly and a crumbling condition induced. We advise keeping the posts in the shade, in an upright position, or in as nearly an upright position as possible, for from 20 to 30 days. We tell them that it is a good precaution to sprinkle the posts several times while curing. We think it advisable not to remove the posts from the molds for at least 24 hrs., and 48 hrs. may be necessary if the weather conditions are unfavorable. We further advise that if the posts are being made for commercial purposes, at least 60 days should elapse in order to give them the thorough curing required before they are hauled or subjected to much lateral strain.

Today the American farmer is unquestionably the greatest consumer of fence posts, with the railroads a close second. The farmer, we find, is more inclined to test by service than to be governed by the result of laboratory processes. The railroads have taken the advice of experts on this subject and have gone at the question in a wholesale fashion. But the farmer wants to try a few posts for a few years, or wants to know what results a neighbor has had.

We must accept this condition and we have plenty of informa-

tion which should go a long way towards convincing any farmer or the manager of a large estate that we do know just what concrete fence posts will do, what they cost, and why it is to their advantage to use them. We are obliged to fight the streak of conservatism that we all possess, and are simply repeating the history of all great inventions and improvements.

While most of us like to pose as progressives, yet in our hearts we are generally "stand-patters." We had our doubts about the telephone, and the electric light was, at first, somewhat of a joke. Concrete pavements were risky experiments; concrete building blocks were at first accepted without a great deal of enthusiasm, and the concrete fence post has been slow in securing the confidence of the public.

We are doing our best to add our share to the education of the masses, and, generally speaking, the educational work is going on in a most satisfactory fashion. The work of the great railroads has been keenly watched by the men through whose land they run. The United States Department of Agriculture has carried on experiments as to the merits and desirability of the concrete post which are very convincing. A number of the leading states of the Union have given the concrete fence post the cordial welcome its importance warrants.

In advocating the use of the concrete fence post, we have one very great advantage. Every thinking man knows that the day of the wooden post is rapidly coming to an end. Even if it were as good as the concrete post—which it is far from being—it is becoming so scarce, and in a very few years it will be extravagance to even think of wood for this purpose.

On the other hand, while nearly everything we eat, wear and use, has appreciated in value, modern methods of making cement have reduced the price of this material, and we do not inquire so closely into its cost of manufacture as into the cost of transporting it to the points at which it is to be used.

Concrete has come into its own in a way that the prophet of twenty years ago would never have dreamed possible. There seems to be no limit to the uses to which concrete can be legitimately adapted. Concrete posts are not among the least of these uses, and in the opinion of many well-informed men the great expansion of the industry during the next few years will be in the use of the concrete fence post.

THE PROBLEMS OF THE CONTRACTOR.

By Leonard C. Wason.*

Introduction.

This paper is written at the suggestion of a friend, who believes that if the engineer and the architect can better understand the problems they put up to the contractor, and can get an insight into the *whole* problem through his eyes, greater efficiency will be obtained in building operations and more harmony in their business relations will result. The writer believes most positively that an engineer and a contractor are both necessary. That no matter how great the ability of any person, and in spite of unlimited help and financial resources, the owner's interests in the long run can be better served by two persons—the engineer and the contractor—working together than by one performing all these duties. If this paper helps to establish permanent team work between the engineer and the contractor, where now is, too frequently, antagonism and misunderstanding, its presentation will have been justified.

The company with which the writer is connected has for nearly 20 years specialized in reinforced-concrete construction. Mill buildings of reinforced concrete for various industrial purposes have constituted the major part of this work. It will be seen in what follows that the day of the contractor has passed whose only written record is a pocket time book and the stubs of a check book, and his methods have been replaced by somewhat intricate ones with elaborate organization. This organization and the methods used are the results of slow development. It is hoped this paper will prove that in solving the contractor's problem of furnishing quick, efficient and economical service the results accomplished justify the methods employed. Everything herein described is based on the personal experience of the writer and of his company.

* President, Aberthaw Construction Company, Boston, Mass.

The subject is considered in two parts. First, the human elements; and second, the mechanical elements of actual construction. For convenience both parts are subdivided, as follows:

HUMAN ELEMENTS.

General relations: With owner; with engineer; with inspector; the superintendent.

THE CONTRACT.

EXECUTION OF CONTRACT—*Mechanical Elements.*

Preliminary work.

Analysis of the design: Minor features; uncommon features; method of drawing details.

Selection and purchase of materials.

MANAGEMENT OF CONSTRUCTION.

Drawings for forms, steel bending and plant.

Plant: Kind, amount, arrangement, methods.

Organization of job force.

Planning, routing and cost accounting.

Weather conditions: Precautions against rain, sun and frost.

GENERAL RELATIONS.

Before taking up the mechanical elements involved in executing a contract, it will be well to consider the human elements which are sometimes paramount to its actual execution.

The Owner.—As sometimes the owner takes an active interest in the execution of the work, although he deals through his engineer or architect, it is of considerable importance to know his temperament and point of view. Greater harmony will thus be obtained. The engineer will do well to bring both parties together early and often. There is the owner who has not been seen at the time of final payment, and the one who is in evidence every day,—the one who has a technical training and knows, and the one who does not know about construction, but thinks he does, and concerns himself with the work commonly considered the engineer's. If the engineer is weak-kneed, with the last-

named type of owner, expense and misunderstanding are almost certain to result, primarily because no man can serve two masters, and secondarily because an ignorant master, the owner, is never satisfied. If there is a very strong, fair-minded engineer who commands the respect of his client, there is little trouble with any type of owner. The worst combination is a fussy owner and an engineer who has obtained his commission by hard chasing, instead of being sought by the owners. The latter is the hardest to control and frequently makes trouble for the contractor thus affecting the cost of the work. The contractor, therefore, seeks to learn the probable conditions before submitting a bid.

The Engineer or Architect.—Then it is necessary to study the engineer or architect and consider his method of handling and supervising work. The methods of some engineers are radically different from those of others; this has a marked bearing upon the cost of the work and sometimes on its desirability to the contractor. The contractor must determine what sort of treatment he will receive. Nothing adds to the price of a bid like uncertainty, whether it be in the temperament of the engineer, of the owner or the unknown construction problems. Usually the engineer or architect intends to be just, but on rare occasions he allows his judgment to be influenced by the attitude of the owner; or, where two different solutions may be possible, for policy's sake or for hope of personal advancement, makes the second best decision. The increased expense which is entailed can never be foreseen, although it certainly exists and has to be paid for as a contingent item of cost. The reputation of the engineer who is always fair spreads far and wide, and he is sought by many responsible contractors who desire to do his work. This results in work being done at the lowest legitimate cost by competent firms; the owner gets a square deal, and by reason thereof continues to employ this engineer, and also recommends him to his friends; he thus, in the long run, prospers more than he could by other methods. Meanwhile, he maintains his self-respect and is justly proud of work well done. Contractors talk rather freely among themselves about their experiences and their opinion of those for whom they have worked, and perhaps oftener than is imagined are asked by owners whom they would recommend to design new work. They certainly exert

an influence on the reputation and also on the business of the engineer.

The Inspector.—One of the great problems which the contractor has to face is the ability of the inspector who represents the engineer on the work. When thoroughly competent he is a great help to the contractor and very beneficial in the results obtained. The most important thing to consider in the appointment of an inexperienced man is his temperament. He must have an even temper not easily ruffled, be considerate, yet firm, always diplomatic, and be capable of performing his duties acceptably to his employer. The superintendent for the contractor is necessarily better informed and trained in construction, is an executive who is constantly directing others and quick to resist for the good of the service insubordination or usurpation of the duties for which he is held to strict account by his employer. In other words, he is trained to be an autocrat. This temperament does not take kindly to being bossed by a younger man with admittedly less experience. Therefore, the inspector must have the above-named qualities and also must not consider it a personal affront when his orders are overruled. He will make some mistakes which the engineer will correct, and many more, alas, which his chief will never hear about, although they cause unnecessary expense and may affect his chief's professional reputation. He is in a trying position, left too much alone, and required to perform certain duties, beyond whose bounds he must not go. Friction is most frequently caused when the inspector assumes to perform duties which do not belong to him. The contractor has a perfect right to object to this, but out of the refusal arise many complications. Judging from results, it would seem that the inspectors are not concisely instructed in their duties and they are not watched closely enough by their chiefs to see that they not only perform their duty but also do not attempt more. The most common mistake of the inspector is to interfere in the conduct of the work by giving the workman orders direct. To permit this would destroy the morale and disorganize the job with far-reaching consequences.

It may be asked why the contractor so seldom protests against the rulings and objections of incompetent inspectors and those who have an alleged grudge to work off. Experience

has proved that the contractor who habitually does this would find it much more profitable to retire from business.

The Superintendent.—The very first step which a contractor must take in starting the execution of a job is that of selecting a general superintendent to handle the work. The type that is hired for a single job and discharged at its completion is not worth having. The really desirable superintendent is obtained by experience, is the survival of the many tried, and when once secured should be retained. Some owners and engineers so appreciate the value of personality that they have given the writer's company contracts on condition that a certain superintendent be placed in charge.

Frederick W. Taylor, in his excellent paper entitled "Shop Management," specifies 9 different qualifications which go to make up a well-rounded man, namely:

> Brains; education; special or technical knowledge; manual dexterity or strength; tact; energy; grit; honesty; judgment or common-sense; and good health."

He states that there are plenty of men to be found who embody 3 of these qualifications. Four make a higher-priced man. A man combining 5 is quite hard to get, and one combining 6, 7 or 8 is almost impossible. If a building superintendent is to be successful, he must combine at least 7 of these qualities. He must have brains, special and technical knowledge of both contract and subcontract work, tact, energy, honesty, judgment and good health. He must have a personality which drives to activity several hundred originally unorganized men who are without special interest in the company or in the result accomplished, and such tact and judgment as to weld them into a harmonious working force, cheerful and self-respecting, with high morale, and ultimately with enthusiasm for the work in hand. He carries a great responsibility as he builds full size, with permanent materials, the structure whose intricacies of design tax the skill of the engineer to show clearly on paper; with an honor so fine that the company is ready to leave its reputation in his hands, to trust him with funds; with special experience so trained that dangerous operations are carried on as a matter of routine, without worry to himself or the company,

yet with a constant oversight of a thousand chances for accident or perhaps death which may occur to the men in his charge; with a forethought so great that he sees ahead and provides for the problems which are to come up perhaps months later; with a temper so good that he never loses self-control under the most provoking circumstances, and is able to take with the best of grace changes in his plans from the office, and to work in that close coöperation with the company which is so necessary to make it an effective contracting organization. Such men have a temperament that responds quickly to criticism or praise. Praise comes sparingly, even when deserved, while criticism is freely meted out. The members of the executive force on any job which is sharply criticised will try to avoid criticism by refusing the slightest responsibility beyond what they believe to be clearly their own. A company sharply criticised by an engineer is likely to do precisely the same thing and will throw on the engineer every bit of responsibility that it can possibly avoid. The attitude of the engineer in this respect is reflected in the execution of the work. One engineer may call attention to a mistake with a letter that is harsh and ends with a sting that leaves a feeling of injustice and soreness in the mind of the recipient. Another, in calling attention by letter to a similar matter, does so in a manner that causes the contractor to jump to correct the trouble cheerfully, quickly and without comment, and also sometimes to do more than was asked.

The local conditions may demand a great deal of tact by the superintendent in the handling of his labor. He is usually equal to the situation.

THE CONTRACT.

The type of contract is manifestly of considerable importance. It is the firm opinion of the writer that the usual lump-sum contract type obtained in competitive bidding does not give an owner the best results. With competitive bidding open to all, the lowest bidder is liable to be one who does not use the best of methods, is looking for all sorts of short cuts, and has frequently a limited amount of experience and capital. It has been often noted that those new in the reinforced-concrete field

under-estimate the difficulty and the cost and do work badly at first, no matter how experienced in other lines. The lowest bidder is squeezed to a price for which it is known he cannot make much, if any, profit, and there is, therefore, every incentive to save expense and slight the work. This condition of necessity encourages mutual suspicion and antagonism, therefore, the best results are impossible. No amount of careful inspection can make an inexperienced or incompefent contractor turn out thoroughly first-class work.

On the other hand, under the cost-plus-fixed-sum-for-profit type of contract, the interests of the owner, builder and engineer are one. Work obtained in this way is certain to be much better for the same cost; even if the cost is slightly greater, the owner has the assurance that he is getting much more for his money. The engineer can examine the estimate of cost as prepared by the contractor, discuss savings or changes, and can see places where he is willing to cut the design, when he knows that there is not going to be still further cuts in the execution of the work. When he knows that the work is going to be executed exactly as designed, he can design with greater precision and economy than when he has to provide extra strength or size of members to allow for a possible lack of quality of materials and workmanship by some unknown person who may secure the execution of the work. The contractor has service to sell, the owner wants results, and where this mutuality exists both parties can accomplish the end for which they are striving. If the owner wants to start as soon as he engages the engineer and before plans are started, he can save about 6 weeks' time with no serious difference in cost on the cost-plus-fixed-sum basis. There are several variations in details with this type of contract. Its merit lies in removing one of the most trying problems of the contractor,—his antagonistic relation to the engineer and the owner.

ANALYSIS OF THE DESIGN.

When a contract is awarded, and a set of plans received from the engineer, a considerable amount of work must be done in the main office, beginning long before any work is started in the field, and continuing in the designing and the purchasing depart-

ments during the early stages of construction. The function of the designing department is to make a careful study of the complete set of plans for the purpose of designing forms, tabulating steel, and illustrating and tabulating such other materials, as doors, windows, architectural iron, etc., when this is not done in the engineer's office. The location of construction and contraction joints is studied, and on rare occasions the structural design is reviewed. In the writer's practice it is common to close a contract and start building before any working drawings are made. Then the work and responsibility thrown on the designing department are very great.

Minor Features.—This term is applied to those parts of the design which are not vital to the construction, and, therefore, frequently are not shown on plans, being left either to be settled in advance by the builder or during construction by the engineer and himself. Knowledge of some of these features is acquired only by experience in actual construction, and may not occur to the engineer until called to his attention. Chief among these minor features requiring attention are the means to be provided to prevent cracks, which mar the appearance and are often a source of annoyance though seldom a cause of structural weakness. There are, sometimes, cracks caused by unequal settlement of foundation, as in the case of a building partly on piles and partly on earth, where it is hard to foresee and provide such an amount of bearing that the whole will settle evenly. Large wall surfaces without joints are very liable to crack vertically, due to the shrinkage stresses in the concrete. Experience has shown that thin walls with insufficient reinforcement will crack about every 25 ft. of their length when exposed to the air on both sides. Thick walls will crack about every 50 ft. Where the wall is exposed to the air on one side only, and kept at a fairly uniform temperature, either by water or earth on the other side, there is very much less danger of cracks.

Where a floor is built around machinery foundations, frequently a long span and a short span beam come close together. Unless provision is made for a joint between them, there is certain to be an unsightly crack, due to the difference in deflection under the same load.

Another important question that must be taken into con-

sideration in the design is whether a granolithic floor is to be laid as an integral part of the construction, or as a second operation, and if so, what its thickness shall be. For economy's sake, both in materials and in labor, it is cheaper to put on the finish with the construction. Under these conditions, it is frequently impossible to keep off the floor long enough for it to harden sufficiently to prevent its being somewhat marred. If this is a serious objection, the finish must be put on as a second operation. As this does not bond sufficiently with the floor to be considered a unit, the construction should be thick enough to carry the load without any assistance from the finish. If the finish is 1 in thick, it is almost safe to guarantee that it will loosen in spots, whereas if 2 in. thick it is safe to guarantee it as solid and satisfactory. This adds to the dead weight and to the expense. It is necessary to settle these points before construction begins in order to secure the minimum of cost and the maximum of efficiency, since it influences the cost of forms and the conduct of the work.

The cleaning and the finishing of the exterior of a building, according to the type of finish specified, whether it is left as it comes from the molds with just the bad places rubbed up, or whether it is to be tooled or plastered, will in some degree affect the design of forms, and, therefore, must be considered before work is begun.

Because concrete is a plastic material cast in place, and because the molds can be made of any design, engineers seem to feel that there is no necessity for holding to standard sizes for the members of a concrete structure, as they do when designing in steel. An engineer can, however, use quite an amount of thought to good advantage in the selection of sizes, as the particular dimensions which best satisfy his designs will quite often not be the most economical. In one building of large size, in a single floor there were in the original design received 455 different sizes and styles of beams. The designing department of the writer's company found it possible, without impairing the result to be accomplished, to reduce these to less than a tenth of the original number, and by coöperation with the engineers finally succeeded in reducing the number to 52.

The question of change of size of columns in every story, or once in 2 or 3 stories, is one of cost. The expense of changing

the forms is usually greater than the cost of concrete saved on small columns where the reduction is less than 3 in., and on large columns where the reduction is less than 2 in. Therefore, it is not often economical to change the size every story. Often when the column is reduced it is desirable to use a head having the size of that of the lowest story columns in order to avoid the expense of splicing out beam and girder sides and bottoms. Sometimes when the upper floor has a lighter load than the lower, it would be possible to reduce the size of the beams. Economy dictates that the depths may be reduced but not their width, because this would require splicing out all the floor panels and joists, the cost of which is more than the value of the concrete saved.

Uncommon Features.—The frequency of uncommon or special features in a lower floor, and the certainty that the basement story height is less than that above, adds to the cost of form work. This occurs at a time in the process of construction when new lumber must be cut up although it could be advantageously used in long lengths on upper stories. If it cannot be used again, it has to be remade, and the remaking of second-hand lumber into new shapes is more expensive than using brand new lumber.

SELECTION AND PURCHASE OF MATERIALS.

The purchasing department is also quite busy, beginning before any work is done at site of building, and always keeping away ahead of construction requirements. As stated above under the head of contract, the contractor is very largely a broker buying materials to be incorporated in a building. Some materials are easy to buy, others require a detailed knowledge of the materials themselves and also of the estimate and contract and the relation of one class of material to another. There is, therefore, a distinction made, classifying the simplest articles and duplicate orders as routine buying, the others as experienced buying. Some routine buying can best be done at the job and some from the main office of the company. There has been compiled a complete list of all materials which enter into a job, and then it must be decided which of the routine items can most advantageously be bought by the main office and which by the

job superintendent, and written instructions are prepared for these items. This table gives in the first column the list of materials, in the second the usual time which it takes to obtain these after placing the order, in the third column some explanatory notes giving necessary information, and in the fourth the time after contract is awarded at which information should be received in order to deliver completed building on time. This time assumes that the ordinary four-story mill building will be completed ready for delivery in four months from award of contract. On this list the great majority of items require information within one week, a few in 2 weeks, and the latest must not be delayed more than a month from award of contract, if the probability of delay is to be avoided. It appears strange and engineers have been surprised when we have asked for full-size window details before the footings are in place, but when it is realized that from 7 to 10 weeks are necessary if the minimum price combined with quality is to be obtained, it will be seen that this request is not unreasonable.

The selection of aggregate for a job in a new locality is often a problem. A decision has to be made before the final design of mixing plant and its location can be determined because team and railroad deliveries will be at different places. The purchasing department never buys an unknown sand until it has been thoroughly investigated by a testing laboratory, although this may cause an annoying delay. The tests continue at intervals throughout the progress of a job. The steel is taken from the plans by one man and checked independently by another. This schedule is then studied with a view to reducing the variety of lengths, which is frequently as much as one-fifth of the number shown on the plans.

MANAGEMENT OF CONSTRUCTION.

In the general management of the construction operations the writer's company has made radical changes from customary practice in the erection of reinforced concrete buildings. As a result of the introduction of the methods described below, the labor cost of making, erecting and removing forms, which is one of the largest items of expense in a reinforced concrete job, has been reduced during the past 4 years over 30 per cent.

the forms is usually greater than the cost of concrete saved on small columns where the reduction is less than 3 in., and on large columns where the reduction is less than 2 in. Therefore, it is not often economical to change the size every story. Often when the column is reduced it is desirable to use a head having the size of that of the lowest story columns in order to avoid the expense of splicing out beam and girder sides and bottoms. Sometimes when the upper floor has a lighter load than the lower, it would be possible to reduce the size of the beams. Economy dictates that the depths may be reduced but not their width, because this would require splicing out all the floor panels and joists, the cost of which is more than the value of the concrete saved.

Uncommon Features.—The frequency of uncommon or special features in a lower floor, and the certainty that the basement story height is less than that above, adds to the cost of form work. This occurs at a time in the process of construction when new lumber must be cut up although it could be advantageously used in long lengths on upper stories. If it cannot be used again, it has to be remade, and the remaking of second-hand lumber into new shapes is more expensive than using brand new lumber.

SELECTION AND PURCHASE OF MATERIALS.

The purchasing department is also quite busy, beginning before any work is done at site of building, and always keeping away ahead of construction requirements. As stated above under the head of contract, the contractor is very largely a broker buying materials to be incorporated in a building. Some materials are easy to buy, others require a detailed knowledge of the materials themselves and also of the estimate and contract and the relation of one class of material to another. There is, therefore, a distinction made, classifying the simplest articles and duplicate orders as routine buying, the others as experienced buying. Some routine buying can best be done at the job and some from the main office of the company. There has been compiled a complete list of all materials which enter into a job, and then it must be decided which of the routine items can most advantageously be bought by the main office and which by the

job superintendent, and written instructions are prepared for these items. This table gives in the first column the list of materials, in the second the usual time which it takes to obtain these after placing the order, in the third column some explanatory notes giving necessary information, and in the fourth the time after contract is awarded at which information should be received in order to deliver completed building on time. This time assumes that the ordinary four-story mill building will be completed ready for delivery in four months from award of contract. On this list the great majority of items require information within one week, a few in 2 weeks, and the latest must not be delayed more than a month from award of contract, if the probability of delay is to be avoided. It appears strange and engineers have been surprised when we have asked for full-size window details before the footings are in place, but when it is realized that from 7 to 10 weeks are necessary if the minimum price combined with quality is to be obtained, it will be seen that this request is not unreasonable.

The selection of aggregate for a job in a new locality is often a problem. A decision has to be made before the final design of mixing plant and its location can be determined because team and railroad deliveries will be at different places. The purchasing department never buys an unknown sand until it has been thoroughly investigated by a testing laboratory, although this may cause an annoying delay. The tests continue at intervals throughout the progress of a job. The steel is taken from the plans by one man and checked independently by another. This schedule is then studied with a view to reducing the variety of lengths, which is frequently as much as one-fifth of the number shown on the plans.

MANAGEMENT OF CONSTRUCTION.

In the general management of the construction operations the writer's company has made radical changes from customary practice in the erection of reinforced concrete buildings. As a result of the introduction of the methods described below, the labor cost of making, erecting and removing forms, which is one of the largest items of expense in a reinforced concrete job, has been reduced during the past 4 years over 30 per cent.

The task has been no small one and is not yet completed. It has involved, as essentials, thorough study of the plant layout, the establishment of standard methods of construction, design and operation, the making of detail plans for forms, the routing of the men and materials, and the establishment of a task and bonus system arranged to give the workmen an appreciable increase in pay for speedy and accurate performance. The new methods have paid from both the standpoint of the contractor and of the owner, permitting smoother operation in the work, and, after making full allowance for increased over-head charges, materially reducing the unit costs.

PLANT.

The study of the amount and location of the mechanical plant must be made immediately after the contract is awarded if work is to be started promptly, as part of it must be put into operation with the very beginning of construction. As considerable depends upon the amount, design and promptness of delivery, as far as economical construction goes, the best thought of the whole organization is given to the subject. For instance, one of the younger men made a study for a large job on basis of one story erected each week. To obtain this rate one mixer and two stories of forms more were required than if the progress was slowed down to a story in 9 working days. Such speed was not demanded. A conference of all corrected the first study at an estimated saving in cost of about $10,000.

The size of the mixing plant is determined by the quantity of concrete to be mixed for the entire job, the time allowed by the contract for mixing, and the maximum quantity required in a single day. Usually this can be accomplished with one mixer, taking as a charge a barrel of cement and aggregates in any proportion.

The method of distribution of concrete through the building requires some consideration. If a building is compact and large masses are placed within a limited area, spouting is desirable. If the building is spread out and quite small quantities of concrete are placed, two-wheeled push carts are used, while if large quantities are required over quite an area, industrial tracks laid on horses and elevated about 18 in. above the forms are run over

the latter to distribute concrete a batch at a time. The amount of track, the number of curves and switches, number of cars and all the minor items down to the last bolt must be carefully determined at the very outset in order to save delay in erection.

There are standard lists of small tools compiled for quick use for jobs of various sizes and characters, so that it is merely necessary to call for schedule 6 or whatever it may be, to start work.

The method and equipment for handling excavation must be settled at the earliest stage in the discussion of plant.

Staging.—A frequent cause of injury to workmen is the breaking of stagings on which they are at work, and the writer believes that this is due to leaving the design and erection to the workmen themselves. Although there may be a large quantity of excellent material ready at hand, it is not uncommon for workmen to pick out inferior stock for building a stage. To avoid these difficulties, the principle has been adopted of designing all stagings in the office for any important work. The stage is laid out, giving dimensions and spacing of lumber, the sizes, number and location of nails; whether the stage is to be built from the ground up, whether it is to be a cantilever from an upper story window, or a swing stage hung by ropes from the roof. The plan states the maximum safe load which it is permitted to carry. Material is selected for the workmen, and before any are allowed to use it, its construction is inspected either by the superintendent or by his authorized representative. In this way as much safety is insured the men as the nature of the undertakings will permit. The men work with assurance of safety and therefore ultimate economy results.

ORGANIZATION OF JOB FORCE.

After the job superintendent is determined upon, he is taken into consultation for every other step that follows. The selection of all his subordinates is made in coöperation with him,—the assistant superintendent, clerical force, carpenter, labor, concrete, steel and other bosses; the principal mechanics and even the leading laborers are all selected in advance from among those working on other jobs. The superintendent, where possible, is given at least one week to study plans and specifications

in coöperation with his principal assistants and the office force, before anybody appears at the site of the work except for the mere purpose of studying local conditions. By this time a well-defined plan has been worked out as to the sequence of various operations, the kind and amount of mechanical plant, and its location; schedules of the materials first needed have been made and orders placed, so that by the time actual operations begin in the field the plans are so matured that there are few false moves. The peak of the superintendent's load is the first few weeks during the organization and starting the work. During this period he should have his full executive force, although each subordinate may not at that time be doing nearly as much as he later will be called upon to do.

PLANNING, ROUTING AND COST ACCOUNTING.

During the early stage of actual construction, the superintendent makes a careful study of the handling of the work from the beginning to the very end, making a detailed schedule of work along the general lines previously determined in the office.

The job office work is in charge of a chief clerk, who in addition to overseeing the work of the material clerk and timekeeper, has also charge of the cost-keeping. The timekeeping methods were described fully in a paper by the writer entitled, "Cost of Concrete Construction as Applied to Buildings," published in the Proceedings of the National Association of Cement Users, Vol. 5, 1909, page 38; and that method is carried out on all jobs at present.

The foremen take a particular interest in cost diagrams, as it is natural to suppose they would. Figures meaning a little larger or smaller cost convey some idea, of course, but the foremen very easily grasp the meaning of a line traveling above or below a red desired cost line. Keeping the foremen keenly alive to the cost of the work they are doing has not been, so far as can be seen, detrimental to their turning out good work. It should always be accompanied, however, by more rigid inspection in the first instant, and explained so that they may definitely understand that any lowering of cost shall be considered detrimental to their interest, unless the quality remains equal to the standard.

The execution of a job is divided into two departments,—the planning and routing, and the operating, the former being in charge of a man conversant enough with our standard methods to plan carefully the different steps of the work and say what to do, while the latter is placed in charge of a practical man of experience, whose duty it is to tell how the work should be performed. Work carried on in this way requires the men to receive orders from two foremen. There is, however, very little trouble encountered by reason of this, as the routing foreman remains in a field office and gives instructions wholly on written slips, and instructs only as to what shall be done. The operating foreman has direct charge of the handling of the labor, to make sure that the work is being done in the proper manner, both as regards safety, appearance and economy.

The form work, under older method of management, was the most difficult to efficiently organize and systematize, and, therefore, this was the first to receive attention under the present system of planning and routing. It was found that this class of work was very easy to systematize, and with much effectiveness, more so than the handling of concrete or of steel reinforcement, although these, to a lesser degree, have been brought into the system.

The method of task and bonus pay is frequently followed on work, and by means of data previously obtained it is possible to ascertain very accurately what the best time should be for doing any particular piece of work. For this tasked time an increase of from 25 to 30 per cent over the usual hourly wage is paid. In the erection of the forms a similar method is followed. All material is moved from the stock piles to the point of erection by common laborers, under the leadership of an efficient moving foreman. The foreman receives all instructions on a written slip. The planning department is able at all times to make sure by so doing that the carpenters have the material they want, when they want it, and where it will be most convenient for their use. No carpenters are allowed to carry lumber, but are restricted to really doing carpenter work.

On the erection of the posts, girts and joists, to support the floor panel forms, instead of erecting each post separately and then putting the girts on top of these, they are assembled as

frames in a horizontal position and erected in large units, much in the same way that a frame house is erected. The work is done by one carpenter with the help of three good laborers. The work which the steel and concrete gangs do is planned by the routing department, but not in quite so much detail as is the case with the form work. The saving which is effected in the concrete work is due to the fact that this planning of the whole job gives in advance fairly accurate information as to just what will be required of the concrete gang each day, and by canvassing the whole job for miscellaneous work, which it can do when not concreting, its efficiency is quite materially increased.

From a study of what precedes, it will be seen that, if every class of labor obeys orders and there is an ample supply of materials, with no lack of information as to the requirements for future work, there will be obtained a smooth running clock-like system resulting in greater economy than is possible by any other method. This system requires about one boss to not over 6 or 8 men, yet enough work can be obtained from these to more than make up the unproductiveness of the bosses not working with their hands.

A slip in any action, or lack of information from the engineers, non-receipt of materials, or trouble with the labor, is as disastrous to the successful operation of the system as is the fumbling in football of a forward pass from the quarter ack by the runner. The coöperation of the engineer is, therefore, most earnestly desired to give full information long in advance of its actual use, in order to prevent any break in the smooth operation of the system.

In spite of the fact that the wages of carpenters have nearly doubled in 20 years, while the quality and intelligence of those who do the work is less (because house and finish carpenters will not do this kind of work as formerly), and in spite also of the great advance in the price of lumber with a falling off in quality, the unit costs obtained by the above system are materially lower than when the job superintendent was left to himself. The total gain in efficiency is about fourfold.

NOTE.

Pages 385 to 512 may be found in the

JOURNAL OF AMERICAN CONCRETE INSTITUTE,

Volume II, Numbers 6 and 7.

DISCUSSION.

Mr. Wood.

MR. FREDERICK WOOD* (*by letter*).—Our experiments have extended over such a brief period that the results obtained are insufficient for drawing conclusions.

We have made a few posts of the designs shown in Fig. 1, using a good concrete mixture, and reinforcing principally with scrap signal wire, and in some instances with other scrap rods convenient for the purpose. Some of these posts have been in use for a year or more, while others have been installed more recently. Up to the present time none has shown an inclination to disintegrate, and, in so far as we are advised, none has been broken in any way.

Our New York Division estimates the approximate cost of wooden posts at 25 cents each, and as the life of the same amounts to but few years, we are of the opinion that the concrete posts will be very much cheaper in the end, as once set in the ground they will last almost indefinitely, unless broken by some unusual exterior force.

As you will observe from Fig. 1, we have designed some of these posts to carry commercial wire fencing of different makes, stretched single wires, and in one instance to carry wooden rails, the latter having been designed for use at points where a little additional ornamentation was desirable. As a result of our further experience we may abandon some of these designs entirely, and in other instances we may revise them to meet such requirements as may be developed by further use of the posts.

Mr. Cushing.

MR. W. C. CUSHING† (*by letter*).—At the September, 1910, meeting of the American Railway Engineering Association, a report on reinforced concrete fence posts was adopted, the recommendation reading as follows:

"In view of the present general use of the D. and A. post molds, the satisfactory results obtained with them, the desirability of using on all divisions, posts of a uniform design, and the advantage of the interchange

* Assistant Engineer, Pennsylvania Railroad, Broad Street Station, Philadelphia, Pa.

† Chief Engineer of Maintenance of Way, Pennsylvania Lines, Pittsburgh, Pa.

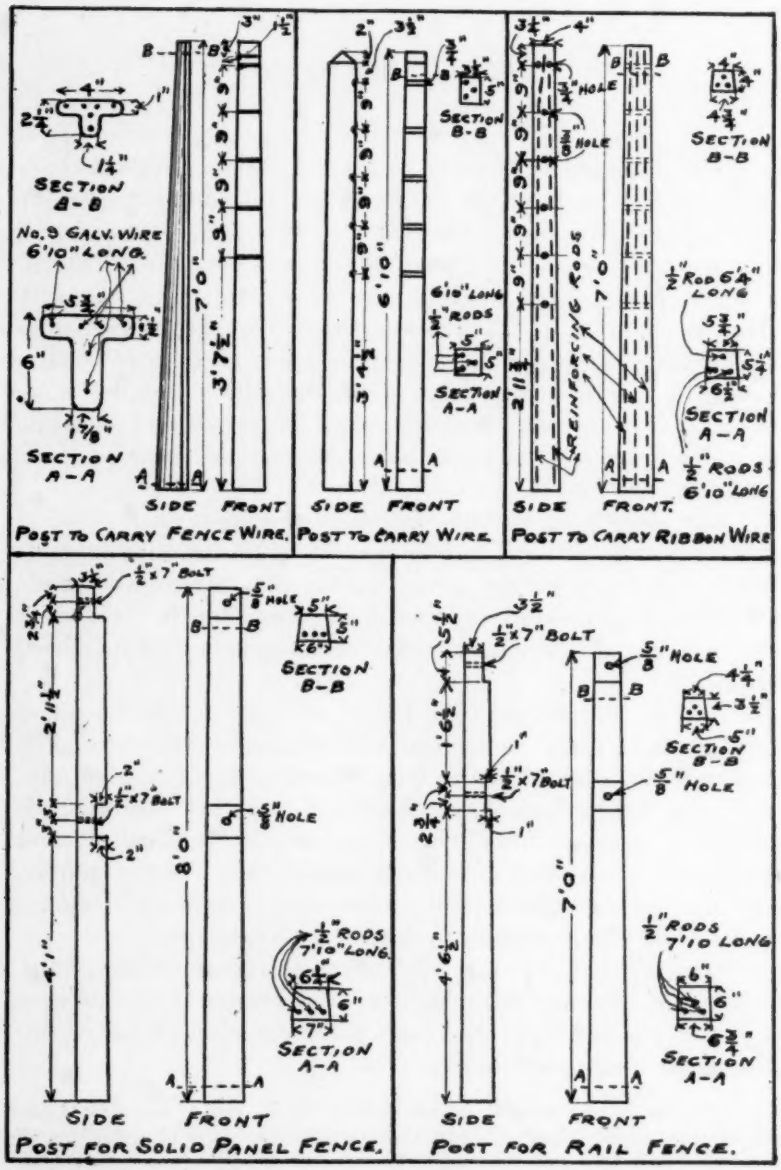


FIG. 1.—TYPES OF REINFORCED-CONCRETE FENCE POSTS, PENNSYLVANIA RAILROAD—NEW YORK DIVISION. JANUARY, 1913. SCALE, ½ IN. = 1 FT.

of information and experience as to the methods of using them, your committee recommends that the D. and A. post molds be used by all divisions desiring to make concrete fence posts, until some other type of post or mold shall be designed which will be more satisfactory." Mr. Cushing.

Since this report was made and up to August 1, 1912, there were ten divisions on the lines west of Pittsburgh and affiliated lines using concrete fence posts, the number on the divisions varying from 220 to 7,600, the total number of line posts in service being over 25,000.

On every division, except one, the D. and A. type of mold was used in manufacturing the posts, the exception being the Indianapolis Division, where 220 staple concrete posts, manufactured by the Never-Rot Post Company of Westerville, Ohio, were in service. Twenty thousand concrete posts have been in service from 1 to 2 years. Five thousand on the Cincinnati Division have been in service since April, 1908. The details of the manufacture have been practically the same, but the reinforcement has varied, being $\frac{5}{8}$-in. No. 18 gage, hoop steel, and in a few posts old barbed wire.

After these posts had been in service a year, it was discovered that with the ground frozen, it was possible to crack some of the posts at the ground line by simply pushing against them. It was also discovered that several posts had broken at the ground line on account of cattle rubbing against them. It is evident that these cracks will open up and allow water to filter into the post, with the probable result that in a short time the reinforcement will be rusted away, causing total failure. Upon further investigation it was found that the reinforcement, in a great number of cases, was not properly placed, thereby weakening the post, and it is now felt that with the class of labor used in the manufacture of the posts and the method of forcing the reinforcement into place, it is practically impossible to secure the proper final position of the reinforcement. The committee has decided that the only certain method of securing the reinforcement in the proper position is to use a wire separator of some form, thereby holding the rods in a certain relation to one another. To this end they have arranged to have several posts made at the Germantown Pit, on the Indianapolis Division, using wire for reinforcing, which seems to give better results than strap iron, and using a small wire separator which will retain the wires in a pre-

Mr. Cushing. determined position. When these posts are made they will be put in service and a report will be made to the Association.

During the years 1911 and 1912, 8,000 line posts, 300 end posts and 200 braces were manufactured on the Indianapolis Division at the Germantown Pit, the cost of the line posts being about 22 cents apiece, the end posts 70 cents, and the braces 75 cents. The costs of the end posts and braces were excessive, due to the small number made, and it is hoped to decrease the cost of the line post, since a rearrangement of the plant has been made. Most of these posts are shipped to other divisions and the results obtained with them will be included in the final report.

We are also considering other designs of reinforcement for concrete fence posts, but in each case they are of recent origin and it is too early to attempt to draw any conclusions. We do not feel that we are yet ready to favor any particular design of reinforced concrete fence post over a good wooden post, such as locust.

Mr. Atwood. MR. P. H. ATWOOD.—If we could adopt a standard test for posts to which all could work, it seems to me it would be a good plan.

Mr. Smith. MR. A. M. SMITH.—I have made and tested different posts, but it is difficult to reach any definite conclusions on the subject; however, I am convinced that it would be a good thing if we could adopt specifications. I think at the present time the more important question is the amount, the size, the placing and the cost of the reinforcement in a post. I would suggest that through a better understanding of the details of construction of a good post, we will be better able to agree upon a specification.

Mr. Bennett. MR. R. B. BENNETT.—Mr. President, all of us are interested in the cement post, and our principal interest should be in making a good post regardless of cost. We should use the same reasoning and the same judgment as in any other problem we might have to solve. When we make an inferior fence post, one that will not stand as it was intended it should, then everything is lost. I think we should all agree to see not how much cheaper but how much better we can make a post. Now, it is necessarily essential to consider the shape of the post, when considering what kind to make. It was stated that the post of triangular section was inferior, because of its shape and the way in which the reinforcement will break. This may be true, to a certain extent,

but the discussion in the letters read from Messrs. Wood and Cushing, of the Pennsylvania Railroad, answers that argument. When this reinforcement is properly spaced and tied together, it is an entirely different proposition; and besides, in the triangular post, there is quite a saving in labor and in weight, and therefore the post can be furnished the consumer at a lower cost. One of the great hindrances to the advancement of the concrete post business has been the fact that the cement manufacturers have sent literature all over the country in which they show the farmer how he can make all the posts he needs with home-made wooden molds. The farmer will make the concrete of any sand available (one that may be full of dirt), use an insufficient quantity of cement and a little barbed wire. When he stretches the wire fencing the post breaks, and then he condemns the concrete post. The United States Government also has been sending out similar literature broadcast; that some of those men in the city of Washington do not know anything practically about a fence post, is proven by their arguments. This kind of publicity is wrong and is hurting the post industry. What we want is a fence post that will stand, regardless of the cost; then we have placed the post question upon a sound foundation. Mr. Bennett.

PRESIDENT HUMPHREY.—Those who ride on the Pennsylvania Railroad between Philadelphia and New York will notice that the right of way is almost entirely lined now, and I expect that in a short time will be entirely fenced with concrete posts. The engineers in charge of that work are very much pleased and have no unfavorable comments to make. I understand that some of these posts were made at a cost as low as 21 cents, and although this cost exceeds that of wood posts, the durability of the former as compared with the latter, would more than justify the use of the concrete post. I would like to ask if any who are interested in the concrete post can give some little idea of the range in price at the present time. I hope they will not try to put the price too low. The President.

MR. SMITH.—Mr. President, it has been my experience in getting around over the country that the average man who makes his own fence posts makes them for something above 20 cents, usually between 20 and 25 cents, and sometimes up to 28 cents. I think sometimes the size of the fence post is a little too small. We are a little too sparing of the concrete. The concrete is not Mr. Smith.

Mr. Smith. very expensive and there is not very much objection to the weight. I like a good, heavy concrete fence post, becaus when you place it in position the weight is a big advantage I think it is a mistake to make the cost of the fence post too low. The average man will expect to get his cost down and will frequently skimp in some way or other. It must be impressed upon the people that the concrete fence post is a permanent improvement and adds so much additional fixed value to the property, if you build your post right, *i. e.*, use enough cement, good aggregate and proper reinforcement. There is no doubt that the concrete fence post is an improvement. But if you make them improperly you are going to have failures and it is the failures that hurt the business. I think there is no better way of advertising the concrete fence post and of getting it before the public than by getting the railroad companies to use concrete fence posts along their right of way, because everybody traveling on, and everybody living along, the railroad will study those posts and observe how they stand up; and you can depend upon it that there will soon be a market for concrete fence posts in the vicinity of that railroad line. As a last word I say do not be sparing of the materials, use plenty of good material, use plenty of reinforcement and use some brains in building the posts. Some people have an idea that you can place the reinforcement in the center of the post. Sometimes you will find all the reinforcement in one side of the post. Therefore, I say let us put a little more brains into this post business with plenty of cement and other proper materials. I am sure that the cement-post manufacturers are more vitally interested in this than almost anybody else. They are very much interested in seeing that the concrete post is made right, so that this business will boom. There is nobody more interested in this than the cement manufacturers.

Mr. Tubesing. MR. W. F. TUBESING.—The concrete fence post is merely a cantilever beam. To determine the proper amount of reinforcement you have to study the side from which the load is going to be applied; that is, if the load is going to be applied from three main sides or from four sides; from the road side and from the farm side, if your wire is correctly placed along the line of the fence your pull will be the same in both directions, so you would only have to measure your reinforcement in a line perpendicular to your wire; you can determine exactly how much

cross-section of concrete you need to take the compression, and also the amount of the reinforcement, which would not have to be large, because the post is not high. So that you can absolutely determine what strength you will obtain with various reinforcements of steel. Mr. Tubesing.

MR. BENNETT.—The pulling test is not a true test. If you make your post strong enough to stand as a fence, that is all that is necessary. What we want is a post strong enough to stand any wire or board fence that might be placed upon it. We have been in the post business since 1903, and we have thousands of our posts in use throughout different states. As far as I know but one post broke and that was above the ground line. There may be others, but we have never had a complaint that a single post has broken off at the ground line. A big horse plunged against and broke off the post I refer to. We use good, clean stone and sand, half and half, and 1 part cement to 3 of the aggregate. Where there is good, clean gravel, we use 1 of cement and 3 of gravel. The material must be clean, absolutely so, and you must use sufficient cement to get proper results; and you must have the reinforcement properly placed in the post. We cannot rely wholly upon the strength of the cement to give strength to the post. It is the reinforcement—the backbone of the post—that gives it its strength. A good cement post that will stand, as Mr. Smith says, can be produced for about 20 to 22 cents in this locality. Of course, in the western states, where the cost of material is higher, the price will be greater; in some localities posts are being produced even as low as 16 or 17 cents—posts that will stand any fence you want to put upon them. Mr. Bennett.

MR. G. H. DOUGHERTY.—The size of the post and determination of its strength are mostly matters of opinion. As regards the amount of reinforcement, for instance, that can be determined by a series of small tests to see which is the most economical for a certain sized post. The ordinary concrete post is not nearly as strong for its size as the average wooden post, nor need it be, for the reason that the wooden post begins to deteriorate from the time it is set, while the concrete post, both theoretically and practically, grows stronger. There is such a thing as a post being so strong as to withstand the maximum load that will ever be pplied to it. Still, there is a way of getting it strong enough, or a little over the average strain that will be applied to it, at an Mr. Dougherty.

Mr. Dougherty. economical cost. A person had better have a few posts fail once in a while than to have them all excessively strong and have a high cost. One inclination has been, not to use the concrete post on account of its cost being so much more than the wood post; if they can be produced and placed on the market at a cost that will compare favorably with the wood post their use will be greatly increased.

Mr. Arp. MR. C. K. ARP.—I do not know much about fence posts, but I would like to know if anybody can tell how much strength is necessary in a fence post and whether or not the fence posts which are made from molds now in the market have been designed to meet that requirement?

Mr. Smith. MR. SMITH.—I have had occasion to use such information as Mr. Arp is seeking but I have never been able to find it. The fence-post business does not seem to be on an engineering basis. Even with the wood post it is not a matter of size, it is largely a matter of what will do the work. In some parts of the country you will find that they use the little Osage orange stakes, not much larger than broomsticks (maybe only a couple of inches in diameter), as hitching posts, and they give satisfaction. So many factors enter into this that it is just a matter of cut and try whatever will suit the case. And as for the required strength of the post, somebody has stated it as the resistance to a charging bull. To design a post to stand the charge of a bull would make an unnecessarily large post. You had better have a post break off now and then than design all your posts of that size. Nevertheless, I would not want to give the impression that the post should be made small, because it should not. It should have good size and if anything, should be rather too large than too small.

A Guest. A GUEST.—Some comments have been made which are very practical; one is as to the matter of the cement companies trying to show the farmers how to make their posts; and the government sending out information in regard to making fence posts. I have seen a good many fence posts; those made by farmers have always been a failure. When the fence-post business gets on a commercial basis and there are manufacturers who spend money in making good posts, then there will be something in the business, both for the cement manufacturers and for the post manufacturers. I live near a government reservation of

twenty-four sections of land. This land has been fenced with posts made according to government instructions. A large number of concrete fence posts has been made and placed; some were reinforced with a few barbed wires and some with about 9 galvanized wires. These posts are all breaking off at the ground, and it is hurting the fence-post business. The surrounding farmers and other people that have seen them say those fence posts are no good. They say, "Look at the government reservation posts made according to the government specifications, they do not stand up." Now they think when a thing is done according to a government specification it ought to be good, whereas in this case it is a failure. Fence posts must be made right. You must have the right mixture, good cement and good, clean sand and aggregate, whether it be gravel or crushed stone, and thoroughly mixed in such a way that every particle of that aggregate is coated with the cement. But the greatest thing of all, in my estimation, is the amount and kind of reinforcement that is used in the posts. If you do not use a sufficient amount of proper reinforcement you are not going to have a good post, that will have stability and will stand up. A Guest.

MR. DOUGHERTY.—I would like to ask the gentleman in what way these concrete posts have failed. Mr. Dougherty.

A GUEST.—All around the tract that I speak of about every third post is broken for some reason or other; possibly the mixture was not right, not the proper aggregate in it to make a good strong post, or there was not enough cement used. A Guest.

MR. DOUGHERTY.—Failures occur either by the post breaking apart, because you have not enough reinforcement, or by the concrete crushing on the side opposite the reinforcement. There is such a thing as a limit of reinforcement in a certain sized post; below and above that limit you have an uneconomical post, because the cost increases much more than the strength will increase with the additional reinforcement. There have been many that talk failures in concrete posts but they do not know how they failed. People are generally quite satisfied with concrete posts but they are always looking for the best one and putting off using them, waiting for somebody else to do so. A large number of perfectly satisfactory posts have been made and I believe that the poorest is at least as good as the average wooden post. Mr. Dougherty.

Mr. Kinney. MR. WILLIAM M. KINNEY.—Several remarks have been made regarding the unsuitability of Bulletin 403 of the U. S. Department of Agriculture entitled "The Construction of Concrete Fence Posts," and publications of various cement companies on the same subject. It occurs to me that if there is any misinformation contained in any of these publications the previous speakers should by all means inform those who have prepared these books. There is no reason, however, why the average farmer cannot make his own posts although they might be better made in a well managed concrete products plant. There are so many locations where it is not possible to buy posts that farmers must make them or go without.

Mr. Dougherty. MR. DOUGHERTY.—I think one of the complaints has been that the posts as a rule have been made with a dry mixture that had to be tamped. My experience has been that it is almost impossible, using a dry mixture to keep reinforcement that does not have a mechanical bond, from slipping through the concrete; with a wet mixture I do not think there is any possibility of slipping. I am sure plain reinforcement is used in many structures in which very little attention, if any, is given to the matter of bond. In the average post the distance from the top of the post to the ground line would be about 2 ft., so that for a wet mixture and any reasonably sized reniforcement there would be more than enough bond to pull that steel in two; if there is not enough bond there is something wrong either with the aggregate, or the cement. But with a dry mixture that will allow the removal of the form as soon as the post is molded, there is not enough bond to keep plain reinforcement from slipping.

Mr. Smith. MR. SMITH.—There is one cause of failure that is often overlooked, and that is the too early handling of posts after they have been molded. Until they have attained strength they should be handled very carefully. Sometimes you see men hauling them out to dry and piling them up the same way they handle wood posts. They throw them on the ground which we all know is not a good thing to do. It may start a very little crack which eventually may open and be called a failure. You must not handle the concrete fence post like a wood post, because it has not the same flexibility, especially just after it is made. It must be handled very carefully until it is say 28 days old. It is much better where it is allowed to stand 2 or 3 months before it is used.

MR. BENNETT.—Unless the concrete post gives good results in service it will not be used. The gentleman who has referred the problem of making good posts back to the post-mold man to see where the trouble is, has offered a very good suggestion. As to the proper reinforcement, we believe that any deformed bar will hold the concrete much better than a smooth bar. We have tried smooth wire, and have had to bend the ends of this wire to keep it from slipping when put to a certain test, but when we used a deformed bar, there was no slipping whatever. There are various types of deformed bars on the market which are very good. We find the quarter-inch twisted square is preferable, because it makes a better bond than the heavier bar and gives a stronger reinforcement than the plain bar. I think the gentlemen who publish this literature should be very careful in their instructions. I have seen, a number of times, printed instructions to make a post of 1 : 3 : 5 mixture; that is, 1 : 8, and pack it into wooden molds. An illustration is given of a wooden mold, and the mixture being tamped, thus showing the farmer how to make posts. The farmer can make a good post, it is true. The farmer wants a good post, but he has tried it so often and met with failure that he is almost discouraged with every type of fence post. When we can produce a good post at as low a price we will place this business on a proper foundation. Mr. Bennett.

MR. ARP.—Your Committee on Cement Products has been asked to draft a specification for fence posts. Now we can test every fence post there is made, and if we get 600 lb. or a 1,000 lb. on the flexure test, what do we know? What we want to know is, what the requirements are as to shape and as to the reinforcement. Now what is necessary to answer these requirements? Mr. Arp.

PRESIDENT HUMPHREY.—The Pennsylvania Railroad investigations are the kind that are going to give us the data we want. For instance, the posts shown in Fig. 1 vary in cross-sectional area from 17 to 39.75 sq. in. at the base, and from 5.56 to 27.5 sq. in. at the top; the reinforcement also varies as to kind and amount. From those posts we are going to obtain some idea as to the average conditions of service. The extreme conditions, as for example a horse running into a fence, are not those for which you must design a post, because you must expect that any material will be broken by some extreme force. If I am not mistaken the American Railway Engineering and Maintenance of Way The President.

The President. Association has a committee that is studying the strength of posts. If the members will send Mr. Arp, the chairman of the Committee on Cement Products, any information that they may have on the question of tests that have been made and suggestions as to the specifications, it will aid his committee in arriving at recommendations, which I hope it will be able to make at our next convention.

Mr. Arp. MR. ARP.—I do not know whether I have a right to make the statement but I happen to be co-operating with the American Railway Engineering and Maintenance of Way Association in making tests on concrete fence posts. We have designed an apparatus for making these tests, and have received 100 posts at our laboratory; I venture to say that when we get through we will know no more about the matter than we do today.

The President. PRESIDENT HUMPHREY.—I am sure the chairman is pessimistic. I, for one, am not willing to accept that statement. Tests may not develop all the facts, but they must develop the fact that one type is better than the other; and we want the committee to tell us which type is best; we do not want it to give us an ideal indestructible post, because that is impossible; but we do want it to say which post is best.

Mr. Smith. MR. SMITH.—It seems to me we are all inclined to be unduly critical and not look at the conditions as they really are today, which I am satisfied are very favorable for the concrete post, whose development I believe is quite satisfactory. We do not have to look very far to find users of concrete posts, on the farms or along the railroads, who are quite well pleased. In communicating with users of posts and in watching work in which large quantities of posts are used it is really interesting and pleasing to note that the concrete post is being taken at its face value and is proving satisfactory.

The President. PRESIDENT HUMPHREY—I think that the friends of the concrete post need not enter into any lengthy defense of it. From the fact that the railroads are adopting it and that you can see posts all over the country, it is evident that this material is here to stay and must be provided for by specifications.

DISCUSSION.*

Mr. D. A. Abrams.—The diagram on page 437 from another series of tests made at the University of Illinois, in addition to those shown on page 432, indicates the percentages of water used in those specimens and shows the effect on the strengths for a wide range of consistencies. I may say that the 13 per cent of water gives a concrete much wetter than that termed the "wet" mix in the other table. That is about as much water as the concrete would retain without leaving a large surplus of free water on the surface. In the series of tests on 6 in. x 6 in. cylinders made at the University of Illinois and reported in Tables IV and V (pp. 435) we have specimens on hand for tests at ages up to 15 or 20 years. Mr. Abrams.

Professor Arthur N. Talbot.——Some further notes about the Illinois tests may be of interest; the Committee outlined rather an elaborate series and we went a little further and made up probably twice as many specimens as they had indicated and now have on hand additional specimens for the different tests for ages of 1 year, 2 years, and so on. Professor Talbot.

Mr. P. H. Bates.—The Bureau of Standards at the Pittsburgh Branch in its experimental work on Portland cement, has used in some cases two different methods of storing the concrete, which may be of particular interest in connection with the present report. So far two series of burns of cement have been made, in the first of which the silica content was held approximately constant and the lime-alumina ratio varied, so that at one end of the series of burns we have a high alumina-iron oxide and a low lime content, and at the other end a low alumina-iron oxide and a high lime content. In the second series we have approximately a constant alumina-iron oxide content and the lime-silica ratio varied. At one end of the series we have high silica and low lime and at the other end low silica and high lime. This relation is shown in Table I which gives the partial analyses, as well as the strengths of 1 : $1\frac{1}{2}$: $4\frac{1}{2}$ gravel Mr. Bates.

* See page 422.

Mr. Bates. concrete, made from these cements, when stored in the damp closet for 4 weeks, and for 26 weeks, and in the air for 26 weeks. It is immediately seen from this table that there is a great difference in the strengths of the material stored in air and in the damp closet for the same period, *i. e.*, 26 weeks. But there is also seen the rather remarkably close relation of the strengths of the material stored for 26 weeks in air and that stored for 4 weeks in the damp closet. In addition to showing the slow gain in strength when stored in air as compared with the much more rapid gain when stored in the damp closet, we have also

TABLE I.—COMPARISON OF COMPRESSIVE STRENGTH IN POUNDS PER SQUARE INCH OF 6 IN. X 12 IN. CONCRETE CYLINDERS.

(1 : 1½ : 4½ GRAVEL CONCRETE.)

Burn Number.	Partial Analysis.			Compressive Strength.		
	SiO^2	R^2O^3	CaO	A*	B†	C‡
20a	23.84	15.50	55.98	836	647	266
19	23.20	13.63	58.17	763	196	117
18	23.40	12.05	60.27	2,291	1,118	812
21	23.47	9.54	62.28	2,396	1,814	1,229
23	23.55	9.52	63.69	3,375	1,429	1,650
24	23.82	7.45	64.14	2,932	1,359	1,551
17	22.78	7.90	65.33	2,802	1,325	1,361
14	26.18	11.13	57.42	1,251	522	260
2a	25.20	11.52	58.39	1,606	756	402
6	24.56	10.98	60.35	1,862	981	730
13	24.30	11.58	60.05	1,969	558	589
15	22.75	10.99	61.94	3,732	1,947	1,526
7	21.70	10.52	64.17	3,182	1,827	1,683
8	19.70	11.96	64.67	2,741	2,011	1,883
10	19.56	12.03	65.07	2,752	2,848	2,367
11	18.22	11.91	66.03	2,920	2,082	2,122
22	18.71	11.08	66.85	3,081	2,207	2,249

* A—Stored in damp closet for 26 weeks. † B—Stored in air closet for 26 weeks. ‡ C—Stored in damp closet for 4 weeks.

brought out the point that the above report calls attention to, *i. e.*, that in order to obtain comparative results it is necessary to age the specimens under as nearly similar conditions as possible. It should be mentioned that by air storage is meant storing in an open building which did not permit precipitation of any kind on the specimens, but subjected them to all the outside temperature changes.

Mr. Skinner. MR. T. H. SKINNER.—I would like to ask Professor Talbot if the curve as shown on page 424 would throw any light on the subject of how far outside of the reinforcing bar the stress which

is in the bar may be supposed to be transmitted into the concrete either when the bar is in compression or in tension; if the strength of the concrete held in restraint by the heads of the machine is increased, would not the adhesion of the concrete to the bar thereby put it in restraint similarly and increase its strength and so affect the strength of the adjacent concrete in the mass? Have you any tests that indicate whether the adhesion of the concrete to the bar would cause it to have a greater strength than normal? Mr. Skinner.

PROFESSOR TALBOT.—Anything in the way of transfer of stress would be carried through the bond from the steel to the concrete or from the concrete to the steel. It is true that in tension the presence of bars would increase the strength, particularly if they are distributed so there would not be a crack all the way through the concrete and the small breakages (if we may call them such), would occur in different cross-sections. If the stress was in the bar there would be a transfer of it to the concrete; if the stress was in the concrete there would be a transfer of it to the bar by means of the bond developed, and both would take the stress. But I do not see in that case that there would be any gain in strength to the concrete due to a short distance. There is one place where the restraint may have an influence, and that is in the compression side of a beam, where on the upper surface there is a maximum stress and below that there is less stress, a pressing of each layer upon the layer above, so that you may expect a beam in the compression area to stand a higher load than where the stress was uniformly distributed over the cross-section. Professor Talbot.

MR. L. C. WASON.—I would ask Professor Talbot if there is any preference between the square specimens and the round specimens in the ratio 2 to 1 of the length to diameter? Mr. Wason.

PROFESSOR TALBOT.—The Committee concluded, as stated on page 423, that the best shape is the cylinder. The prisms gave slightly higher values than the cylinders. There is not as much difference as perhaps the members of the Committee expected to find, and it is very fortunate that this is so, because the results of tests made on the two forms of test pieces can be compared fairly well. Professor Talbot.

Mr. Seaton. MR. R. A. SEATON.—The tests indicate that when the specimen tested is damp it shows a lower strength than when it is allowed to dry before being tested. Are the specimens to be dried out for some little time before testing or are they to be tested in the damp state?

Professor Talbot. PROFESSOR TALBOT.—The Committee has not come to any conclusion on that point. The usual practice is to store the specimens in a room for a short time before testing, long enough to dry out, perhaps a day or so. I think that that is a matter which ought to be considered further. We hope to find the effect of the drying out on the test piece and to determine what is the best method to recommend.

Mr. Tubesing. MR. W. F. TUBESING.—I would like to ask Professor Talbot whether his conclusions are that there was no difference in the strength of concrete made of the different sized aggregates?

Professor Talbot. PROFESSOR TALBOT.—The Committee had the idea in advance that there would be considerable variation in larger pieces, the specimens using larger aggregate giving higher results; but these tests do not bear that out. The general belief is that the larger aggregate gives higher results.

Mr. Boynton. MR. C. W. BOYNTON.—On page 425 it states, "The diameter should not be less than 6 in. except with very fine stone, when 4 in. may be adopted." I understand the Committee is working with concrete materials, both fine and coarse aggregate. Is not that statement apt to be misunderstood? Can we not safely use the smaller cylinder for sand, for instance?

Professor Talbot. PROFESSOR TALBOT.—I think perhaps that should be modified in form as referring to concrete only. The smallest size of test piece which could be used with concrete made up of an ordinary size of aggregate was under discussion by the Committee, and whether they should recommend the compression test piece also for sand. I have no doubt that smaller test pieces than 4 in. could well be used.

Mr. Boynton. MR. BOYNTON.—In our own work we have found it very desirable to make compression tests of sand mortars in the examination of sand, and without anything really to guide us excepting a belief that we could get satisfactory and comparable results we adopted a 3 in. by 6 in. cylinder. If there is any reason why we should not use this shape we would be glad to

discard it; otherwise we wish to continue. On page 426, paragraph 3 reads— Mr. Boynton.

> "For field tests of concrete in actual construction, concrete should be taken from the loose mass after it is dumped from the barrow or other receptacle and before it is tamped or otherwise compacted."

Why should not we take that from the mixer spout rather than from its final place of rest? It seems to me in building construction it would simplify the matter very much to be able to make the specimen on the ground rather than where the concrete is being placed.

MR. CLOYD M. CHAPMAN.—That paragraph covers such cases where the concrete is transported long distances. We desire to know the strength of the concrete that goes into the form. When we sample the concrete at the mixer and then transport it by various methods which might have a bad effect, such as a jarring that would force the cement to the top and the stone to the bottom, or so long a time would be required to transport it that it would get an initial set, we do not test the concrete that is used; therefore, the sample is taken as the concrete goes into the form. Mr. Chapman.

PROFESSOR TALBOT.—The Committee further discussed the case where the material was transported through chutes into a tank from which it was fed into wheel barrows. In most cases it will be easier to take the sample direct on the work than it would to take it at the mixer, where there is not any very good way of sampling. Professor Talbot.

MR. R. J. WIG.—There is a † after the word "California" in Table IV, page 435, and the statement, "This column not included in average curves because of difference in the conditions." As the results obtained are similar to those obtained at the University of Illinois, will Professor Talbot state in what way the conditions were not the same as those of the University of Illinois? Mr. Wig.

PROFESSOR TALBOT.—I do not know. Those particular results are from later tests that the University of California made when it found it had not fulfilled some of the conditions set forth by the Committee. Professor Talbot.

Mr. Tubesing. MR. TUBESING.—On page 432 the percentage of water stated on the Wisconsin curve is 12 and that on the Illinois curve 10.2. The strength, at 28 days, of what the University of Wisconsin calls wet concrete is about half that of what the University of Illinois calls wet concrete. There is such a big difference that it puts a crimp in the real wet mixture.

Professor Talbot. PROFESSOR TALBOT.—There may, of course, be other differences due to the aggregate, but the principal part I should say was due to the percentage of water. Now I do not believe that anybody is using in actual work anywhere near as much water as 12 or 13 per cent.

Mr. Kinney. MR. WILLIAM M. KINNEY.—Referring to Mr. Wig's question. The difference was due to the fact that the specimens which should have been comparable were made on different days, thus rendering a comparison of little value because of variations in humidity, temperature, etc., from day to day.

Mr. Wilson. MR. E. B. WILSON.—Referring to paragraph 5, page 426, I would like to ask whether there is to be any period of storage at the structure under ordinary building conditions? Tests of specimens stored in sand then in the laboratory for several weeks would not give any line on the strength of the concrete in the work. Should not the specimen be stored and cured on the job in such manner as to give results which would mean something?

Professor Talbot. PROFESSOR TALBOT.—The period of storage is only until they would be hard enough for safe removal and so that in shipment they would not dry out. The treatment depends on the purpose of the test. If the purpose is to find whether the concrete put into that building as taken from the mix is up to what might be specified or expected, then it is only necessary to keep the test pieces under constant laboratory conditions, and there would be no advantage in having the storage conditions the same as the conditions on the work. Now there are cases, of course, where you desire to know just what the concrete is in the building under the same conditions of temperature, and storage as those at the building.

Mr. Boynton. MR. BOYNTON.—I believe that the report of the Committee will be read carefully by practically all builders and engineers, and I believe it necessary, for that very reason to develop some points on which the report is not clear. Mr. Chapman gave a

very good reason why possibly the specimens should not be made at the mixer, but I think we all have seen many times where a sample taken from a mass of concrete dumped from a buggy or wheel barrow would be badly segregated; and unless that concrete was remixed it would not be uniform. I do not think we should aim at definite results and then take material from a mass of concrete which is spread on a floor or dumped from a wheelbarrow. If the wheelbarrow has to travel 200 ft. we have one condition; and if it has to travel 20 ft. we have another. Mr. Boynton.

PRESIDENT HUMPHREY.—It seems to me that the conditions for sampling the concrete for the test piece will depend entirely on the purpose of the test. If it is a test of the concrete as it goes into the structure manifestly the sample should be taken from the concrete as it goes into the structure; if it is to test the material then the best way is to take it at the mixer. The amount of water used in mixing is also an important factor. A very sloppy mixture would be very much segregated by carrying in a wheelbarrow. Concrete of the consistency recommended would not have very much segregation after fairly long transportation. But I should think the purpose of this recommendation was to get the strength of the concrete that was going into the work and therefore it would seem that the most logical time to sample it would be just before it was placed in position. The President.

MR. BOYNTON.—I recognize that such is the condition after the concrete is dumped. If you run a wheelbarrow to the place where the concrete is to be dumped and if it is fairly wet and has been trundled a long distance, segregation occurs. Whether the concrete now should be remixed in the wheelbarrow or simply taken at random are points which interest us. It is true that we today are favoring a dryer concrete or a sticky mass. Unfortunately the builder is drifting the other way as fast as he is allowed to go. The spouting of concrete is more prevalent than ever before. We can imagine all kinds of conditions at the end of the spout. If the concrete refuses to flow more water is added; where it flows too freely on a steep grade less water is used. Mr. Boynton.

MR. CHAPMAN.—Probably all of us have had experience in the depositing of concrete. It seems to me that this paragraph 3 (page 426) as worded is reasonably concise. The sample is taken after the material has reached its resting place but before it is tamped. Mr. Chapman.

Mr. Wig. MR. WIG.—There is an objection to taking the sample before the concrete is dumped. As has been pointed out, the spout is usually placed in the center of the form and the material permitted to flow out to the edges. The concrete at the edges is of very different quality from that at the center. This has been demonstrated by an inspection of many railroad and other structures in which the condition of the concrete on the edges was found to be very bad. Therefore, I believe the samples of concrete should be taken from the forms. One other matter that should be brought to the attention of the Committee for further investigation, is the determination of the yield point of concrete as well as the ultimate strength. Should not the yield point of concrete, rather than the ultimate strength be the governing figure in our calculations?

Mr. Kinney. MR. KINNEY.—I believe there is a misunderstanding as to just what the work of this Committee has been up to this time. Most of the tests to date have been made to establish methods of testing which would give the most uniform and concordant results. The recommendations under paragraph 3 (page 426), may be found at a later date to be incorrect. Only by having one variable and conducting tests along these lines can this be established. In tests of concrete the yield point and ultimate crushing strength are so nearly the same that the refinement seems hardly worthy of consideration.

Mr. Tubesing. MR. TUBESING.—In our work I have noticed that the quality of the concrete depends largely on the man who is doing the spading. If we do not have a reliable man doing the spading, so that the aggregate gets mixed with the cement as it is delivered from the spout, we get a very poor concrete. The specimens really ought to be taken after the concrete is spaded, so as to get the right consistency; that is the condition you want.

Mr. Kinney. MR. KINNEY.—A careful reading of the report will show that field tests of specimens cut from concrete as actually deposited have already been suggested. Such tests will establish a definite ratio between specimens as cut from concrete placed in the usual way and those molded in the laboratory. It must be remembered that the work of this Committee is only in its earliest stages. It will take years of study to make the report a complete one.

DISCUSSION.*

Mr. Cloyd M. Chapman.—Mr. President, I am sorry that I am not in a position to discuss this paper; but I do not want to let pass the opportunity for complimenting the metal lath manufacturers on undertaking such a series of tests and being willing to announce in advance, that they will make public all the results. Too often when a particular specialized material is promoted by manufacturers they take pains to prevent any information getting out that is not absolutely favorable; they will not admit the possibility of there being anything wrong. And when a group of manufacturers will admit that people have had trouble with their materials and are willing to submit to making all results public I think they deserve to be congratulated and complimented. Mr. Chapman.

Mr. Allen Brett.—I dislike to make any suggestions that might be construed as in any way criticizing this report. Inasmuch, however, as it is a very able report, it is to be regretted that the Bureau of Standards was not able to buy in the open market all the metal lath used in the tests. This would have eliminated having these samples submitted by the metal lath manufacturers, which might throw a shadow over the results of the tests. Mr. Brett.

Mr. H. B. McMaster.—I think, Mr. President, that the criticism is well made by Mr. Brett, and if we were to do it over again I think that course would be followed. But no one suggested it at the time, there was no thought of any one having any motives other than to act square, open and above board. Mr. Pearson says in his report, there is only one sample that has evidence of having a little over-painting. I do not know just what he had in his mind. His criticism seems to be that it had a little better protection than it would have had under ordinary conditions. I know from my contact with the manufacturers that we have tried very hard to have it right and fair. Mr. McMaster.

* See page 445.

Mr. Bates. MR. P. H. BATES.—Did I understand that all the metal used was Bessemer steel?

Mr. McMaster. MR. MCMASTER.—That was Mr. Pearson's report, but there were some grades of lath, I think, that were open hearth; and I am inclined to think most of them were. Mr. Bartlett, of the Northwestern Expanded Metal Company is here and I ask him if most expanded metal lath is not made from open hearth rather than Bessemer steel.

Mr. Bartlett. MR. WARREN G. BARTLETT.—A great deal of it is, but unquestionably there is a great deal more of it that is Bessemer.

Mr. Bates. MR. BATES.—Do I understand from the report that the galvanized metal is showing poorer results than the painted metal?

Mr. McMaster. MR. MCMASTER.—No, that was not the substance of the report at all. I think it states that the galvanized lath came up to the expectation, and that it would require quite a number of years to demonstrate any failure in galvanizing as a coating; the further statement is made that there was an apparent distinction between galvanizing before the metal was expanded and after. Perhaps sufficient time has not elapsed to demonstrate all the weaknesses. The report states quite emphatically that the sherardizing up to this time shows no greater protective qualities than ordinary painting. The fact that I would bring out is that although the use of Bessemer or open hearth steel in metal ath is very general and probably forms the larger part of the material on the market, I believe it has been found in a study of the corrosion of steel that material like ingot iron and toncan metal corrodes more slowly. If this be so, it would be better, possibly, to make lath out of this class of material. Furthermore, it has been found that the addition of copper to steel has a marked influence in decreasing the rate of corrosion, and possibly the use of material of that kind would be desirable. Mr. Pearson's study of these irons is mentioned in his paper also. He is endeavoring to institute further investigations to determine something of the rust resisting values of these different patent irons.

Mr. Wig. MR. R. J. WIG.—It might be of interest to some to know that the Reclamation Service, in co-operation with the Bureau of Standards, is now about to place a number of steel culverts or flumes on its projects to determine the relative resistance to

corrosion of various metals exposed to the alkali soils of the west. I do not think it has been definitely established that ingot iron is under certain conditions better than Bessemer or open hearth steel. Mr. Wig.

MR. T. H. SKINNER.—I notice that there were a great many panels in the structure shown all relatively small and also a great many partitions. Now these panels were necessarily at varying levels and at variable distances from the outside air; and as great variation in the humidity at different points in the structure was certainly possible—and my experience with stucco on lath has been that the greater dampness near the ground has affected it more than anything else,—I wonder if in the final report the location of those panels could not be explained more clearly, as their position would possibly have more bearing on the ratio of rust on them than the material would. Certainly the relative humidity in the test structure must have varied greatly between the floor and the roof, particularly immediately after rains; and the details do not show in any way the position of those panels. I do not think it is fair to the materials to simply give their rating at any particular time without showing their position. I suppose that information is available at the Bureau of Standards and it seems to me position should have a bearing in the ultimate condition and final report. Mr. Skinner.

MR. MCMASTER.—I think that is a very valuable suggestion. When I visited the Bureau to observe the test house I noticed that the partitions were kept wet although I have now forgotten by what means. They are separated from the ground so that you would think the ground moisture could not reach the specimens. Contrary to general belief it is the experience of manufacturers and users of wire fence that corrosion starts not near the ground but in the upper part of the fence, away from the ground, at which point it is the most damaging. Mr. McMaster.

DISCUSSION.*

Mr. Chapman. MR. CLOYD M. CHAPMAN.—I will explain briefly the reason for the paper on lime putty and cream of lime. The Committee on Treatment of Concrete Surfaces feels that if lime is to be added to stucco or mortar it should be very thoroughly distributed. That distribution is rather difficult with lime putty. If the lime after slacking and reducing to a putty is further thinned with water to the consistency of cream and added to the cement and sand mixture in that condition, it is much easier to get a fairly uniform mixture. The difficulty is in not knowing the amount of lime in a given quantity of cream of lime. There did not seem to be any data available by which one could determine how much lime would be in say a 12 quart bucket of cream of lime, assuming that you supplied the lime to a mortar mixer by measuring it in buckets. So in order to obtain such data these tests were undertaken. Now there were eight dealers in New York City who were asked to submit 5 lb. samples of their lime. Four were high calcium limes and only two were dolometic limes. The analyses were partly supplied by the manufacturers and partly made in the laboratory of Westinghouse, Church, Kerr and Company.

Mr. Wig. MR. R. J. WIG.—Does the kind of putty depend on whether it is made from dolomitic or high calcium lime?

Mr. Chapman. MR. CHAPMAN.—The number of samples tested was small, only ten, and before such data is adopted it should be verified by a series of tests with lime from all over the country. The average gallons of water per barrel of about 24 as against 30 to make putty, is explained possibly by the fact, that the latter amount is for high calcium lime, and the former is for the low calcium lime.

Mr. Bates. MR. P. H. BATES.—How do you make the putty? Do you add all the water at once or only part at a time?

Mr. Chapman. MR. CHAPMAN.—The putty was made by adding all the water at once in a wide mouth glass bottle to which was attached

* See page 459.

a glass reflex condenser, so that none of it escaped. That is, under laboratory conditions, with all the materials at the temperature of the room, and adding all the water at once, about 20 per cent of the water was evaporated. It would be almost impossible on the work to know the amount of water which had been added to a barrel of lime, because a considerable portion of it is evaporated; that is the reason for not starting with putty on the work, because by using the cream of lime you know at once how much water is lost. Mr. Chapman.

MR. P. H. WILSON.—What is the measure of the lime, and was it used uniformly, regardless of the specific gravity of the lime itself? Mr. Wilson.

MR. CHAPMAN.—Yes, assuming that a barrel of lime is 200 lb.; we measured all samples by that unit. Mr. Chapman.

MR. BATES.—Was anything done to chart up the curve through actually determining by analysis the amount of lime in the cream? Mr. Bates.

MR. CHAPMAN.—No, not by making an analysis, but by measuring the quantity of water used in the cream. None of the lime evaporates. We start with $\frac{1}{20}$ lb. of water and we know that we have $\frac{1}{20}$ lb. when we are through. The curve was developed from a series of experiments. The amount of lime in 1 cu. ft. of putty and of cream of lime was actually determined and then the curve for putty was drawn. In going over this data I found that there were two that did not check; on investigation from the analysis it was found that there was a mathematical mistake in calculation, *i. e.*, the curve showed a mathematical error. Mr. Chapman.

DISCUSSION.*

Mr. Kinney. MR. WILLIAM M. KINNEY.—If in one of the systems shown the concrete is supposed to be elevated in a bucket elevator, I wish to call attention to the possible loss of water and mortar. This would collect at the bottom of the elevator and mean either the use of a quantity of partially hardened concrete or a large resultant loss. In general the best practice is to elevate single batches of concrete as units.

Mr. Hanson. MR. E. S. HANSON.—I have noticed many times where a system of this kind is used, that the elevator buckets do not empty the pit completely, so that some of the concrete is likely to take a partial set before it is used.

Mr. Cline. MR. A. E. CLINE.—One type of plant that Mr. Hanson did not refer to may be of interest. It was built for the manufacture of four different products, viz., cement blocks, sewer pipe, hollow building tile and ornamental stone. The building was rectangular in form. The railway was at one end. The bins were on the floor. The sand and aggregate were wheeled from the car and dumped on the second floor in separate bins. The mixers were all placed under the second floor that was 16 ft. above the first. A 7 cu. ft. bottom dumping car was used, into which was drawn from the bins the sand, gravel or stone, and the bags of cement required for the mixture; a small freight elevator carried the car to the floor above, it was run directly over the mixer, the material was dumped, mixed dry, then the water added, and when the mixing was complete the mixture was dumped into a chute. This chute led directly to the machine in which it was molded into pipe, blocks or tile, which were carried to the kiln or curing room on three-deck cars. The kilns were similar to those shown by Mr. Hanson, in that the transfer track ran across the building, the kilns at one end and the machines at the other. The roof of these kilns, 7 ft. high, was a 6 in. reinforced concrete slab that formed the floor of the ornamental stone room above. All was combined in one building of about 90 by 150 ft. The doors from the kilns opened from the outside at the end of the

* See page 485.

building, where another transfer track took the cars directly to the storage yard. This is a system of bringing the material to the mixer that I have never seen in any other plant, and it has worked very successfully, especially since we could vary the mix with every batch. We used batch mixers and if we found one proportion did not work quite right we could change it in the next batch, without the trouble or delay involved where two or three hopper bins feed directly into a continuous mixer, which method I find a very poor one. The cost of putting in that small freight elevator was a good deal less than the cost of elevated bins; and it was found to be a very handy arrangement. Mr. Cline.

MR. H. S. RAYMOND.—We have had considerable trouble with our kiln doors and with our canvas, which we have remedied in this manner. We substituted the very lightest galvanized sheet metal instead of canvas, and now have no trouble with our kiln doors; we use about a No. 28 or 30 gage galvanized steel. This does away with rotting canvas, it is only a trifle heavier and is more economical in the long run. Mr. Raymond.

MR. HANSON.—I would like to ask the gentleman if he has had those doors in use long enough to know what their life is likely to be. Mr. Hanson.

MR. RAYMOND.—No; the steel was placed about a year ago. The longest life of the canvas is only about 18 months or 2 years. We have had no trouble with the light steel. Mr. Raymond.

MR. A. E. RICHARDSON.—I have used galvanized iron in my plant for 8 years and it is as good today as when it was put in. I have had kilns or steam-curing rooms in use for 9 years; I built the first in this country. Mr. Richardson.

MR. J. J. BERRYMAN.—I have tried for 2 years, all but 2 months, the use of light roofing, and it has given excellent service; I make a light framework and hinge it at the top. It shows no signs of playing out; it is easily done, and makes a light door that is cheap. Mr. Berryman.

MR. RAYMOND.—We have tried using tar roofing paper on our kiln doors but it only lasted 6 months. When dry it was so hard that it warped out of shape and when wet the nails would not hold. It was not much lighter than the light galvanized steel which is giving good service and which keeps the draft out of the kiln and is also much warmer in winter. Mr. Raymond.

Mr. Stubbs. MR. R. C. STUBBS.—The feature I wish to call attention to is conveying concrete after it has been mixed. In my business, the pavement business, I eliminate by my specifications the use of carts in conveying concrete. Instead I cart the dry batch to the machine, add the water, complete the mixing and deposit directly from the mixer. I wish to emphasize the fact that conveying concrete is likely to induce segregation. I consider carting concrete bad practice. Concrete should be placed as soon as it is mixed.

The President. PRESIDENT HUMPHREY.—There is a method of conveying concrete that has been tried in Europe, viz., of having a central plant and conveying the mixed concrete in carts to the place of deposit. I think concrete has been conveyed in that way about 3 miles; a contractor having work at different places, simply carts the concrete from a centrally located mixing plant. Tests made of the concrete have given extraordinary results and the method is very interesting. I do not know that I want to recommend that practice in this country, and certainly not with the wet mixtures commonly used. The jolting of the cart would tend to produce a separation of the large and small aggregate. The method described I saw in use in Hamburg only. They took care of the setting in the summer time by using a double wall cart, or a cart with a little insulation, and by placing a canvas over the top to prevent the heat from affecting it by evaporating the water and causing hardening by drying; in that way the concrete showed no evidence of setting a couple of hours after it was mixed.

Mr. Zeidler. MR. ZEIDLER.—I would like to ask whether you think the cement we use in this country would stand a 3 mile trip under ordinary conditions? Was the cement that was used in this particular place in Germany a 60-minute cement or was it a much slower setting cement?

The President. PRESIDENT HUMPHREY.—No, a standard cement was used; a cement may set in 35 minutes, but when you add sand and stone to it the resulting concrete sets much more slowly. I think the method of carrying practically controlled or retarded the setting. They mixed the concrete quite a long time, and as deposited it was certainly of most excellent quality, and the compression tests of that concrete were higher than you ordinarily obtain.

CHARTER

OF

THE NATIONAL ASSOCIATION OF CEMENT USERS.

KNOW ALL MEN BY THESE PRESENTS, That we, the undersigned, all of whom are citizens of the United States, and a majority of whom are residents of the District of Columbia, have associated ourselves together for the purpose hereinafter set forth and desiring that we may be incorporated as an Association under sub-chapter three (3) of the Incorporation Laws of the District of Columbia, as provided in the Code of Law of the District of Columbia, enacted by Congress and approved by the President of the United States, do hereby certify:

1. Name. The name of the proposed corporation is "The National Association of Cement Users."

2. Term of Existence. The existence of the said corporation shall be perpetual.

3. Objects. The particular business and objects of the said corporation shall be to disseminate information and experience upon and to promote the best methods to be employed in the various uses of cement by means of convention, the reading and discussion of papers upon materials of a cement nature and their uses, by social and friendly intercourse at such conventions, the exhibition and study of materials, machinery and methods and to circulate among its members by means of publications the information thus obtained.

4. Incorporators. The number of its managers for the first year shall be fifteen.

In Witness Whereof, we have hereunto set our hands and seals this fourteenth day of December, A. D. 1906.

RICHARD L. HUMPHREY, (SEAL)
JOHN STEPHEN SEWELL, (SEAL)
S. S. VOORHEES. (SEAL)

OFFICE OF RECORDER OF DEEDS,
DISTRICT OF COLUMBIA.

This is to certify that the foregoing is a true and verified copy of a Certificate of Incorporation, and of the whole of such Certificate as received for record in this office at 9.49 A. M., the 19th day of December, A. D. 1906.

In testimony whereof I have hereunto set my hand and affixed the seal of this office, this 20th day of December, A. D. 1906.

(Signed) R. W. DUTTON,
Deputy Recorder of Deeds,
District of Columbia.

(SEAL)

CHANGE IN TITLE OF ORGANIZATION

FROM

NATIONAL ASSOCIATION OF CEMENT USERS

TO

AMERICAN CONCRETE INSTITUTE.

At the Eighth Annual Convention of the National Association of Cement Users, held in Kansas City, March 11–16, 1912, the desirability of changing the name of the Organization to one more indicative of its work was discussed at length and on motion "the matter was referred to the Executive Board, with authority to effect a change in name if deemed expedient for the best interests of the Association."

After careful consideration for more than a year, the Board of Direction of the Association deemed that a more suitable name was desirable for the Organization and took the necessary steps and the change in the name was effected as set forth in the following documents, which are recorded in the office of the Recorder of Deeds, in the District of Columbia, Washington, D. C.:

MAY 29, 1913.

We, the undersigned, members of the Board of Direction of the National Association of Cement Users, hereby authorize the President of this Association to take such legal steps as may be necessary to effect a change, July 1, 1913, in its name from National Association of Cement Users to American Concrete Institute:

President:	RICHARD L. HUMPHREY.
Vice-President:	A. N. TALBOT.
	LEONARD C. WASON.
Treasurer:	HENRY H. QUIMBY.
Secretary:	EDWARD E. KRAUSS.
Directors:	C. DERLETH, JR.,
	B. F. AFFLECK,
	W. P. ANDERSON,
	ERNEST L. RANSOME,
	EDWARD D. BOYER,
	W. L. CHURCH.

We, respectively, the President and Secretary of the National Association of Cement Users, hereby certify that the foregoing and annexed consent in writing to the change of name of the National Association of Cement Users to American Concrete Institute, bears the genuine signatures of all the trustees or directors of the National Association of Cement Users, who were on the date thereof directors or trustees of the said National Association of Cement Users, and we further certify that the original name of the Association or Corporation is the National Association of Cement Users and the new name of the same is to be American Concrete Institute, and that the corporate existence as continued shall be perpetual; that the business of the said corporation shall continue as set forth in the original certificate of incorporation.

In Witness Whereof we have hereunto set our hands and seals this 1st day of July, A. D. 1913.

RICHARD L. HUMPHREY,
President.

[CORPORATE SEAL]

EDWARD E. KRAUSS,
Secretary.

UNITED STATES OF AMERICA.

COUNTY OF PHILADELPHIA, } *ss:*
STATE OF PENNSYLVANIA, }

I, Ruth B. Summerill, a notary public in and for the Commonwealth of Pennsylvania, residing in the city of Philadelphia, do hereby certify that Richard L. Humphrey and Edward E. Krauss, parties to the annexed certificate of change of name of the corporation of the National Association of Cement Users which is to be changed to American Concrete Institute bearing date on the first day of July, A.D. 1913, personally appeared before me in said City of Philadelphia, State of Pennsylvania, the said Richard L. Humphrey and Edward E. Krauss, being personally known to me to be persons who made and signed the said certificate of change of name, and acknowledged the same to be their act and deed for the purposes therein set forth.

Witness my hand and seal this 1st day of July, 1913.

RUTH B. SUMMERILL,
Notary Public.

[NOTARIAL SEAL]

Commission expires Feb. 21st, 1915.

OFFICE OF THE RECORDER OF DEEDS,
DISTRICT OF COLUMBIA.

This is to certify that the foregoing is a true and verified copy of the Certificate of Incorporation changing the name of the National Association of Cement Users to American Concrete Institute and of the whole of said Certificate of Incorporation, as filed in this office the 2d day of July, 1913, and recorded in Liber No. 30, folio 77, et seq., one of the Incorporation Records of the District of Columbia.

In testimony whereof I have hereunto set my hand and affixed the seal of this office this 28th day of July, A.D. 1913.

[SEAL]

R. W. DUTTON,
Deputy Recorder of Deeds, D. C.

BY-LAWS.

ARTICLE I.

MEMBERS.

SECTION 1. Any person engaged in the construction or maintenance of work in which cement is used, or qualified by business relations or practical experience to co-operate in the purposes of this Institute, or engaged in the manufacture or sale of machinery or supplies for cement users, or a man who has attained eminence in the field of engineering, architecture or applied science, is eligible for membership.

SEC. 2. A firm or company shall be treated as a single member.

SEC. 3. Any member contributing annually twenty or more dollars in addition to the regular dues shall be designated and listed as a Contributing Member.

SEC. 4. Application for membership shall be made to the Secretary on a form prescribed by the Board of Direction. The Secretary shall submit monthly or oftener if necessary to each member of the Board of Direction for letter ballot a list of all applicants for membership on hand at that time with a statement of the qualifications, and a two-thirds majority of the members of the Board shall be necessary to an election.

Applicants for membership shall be qualified upon notification of election by the Secretary by the payment of the annual dues, and unless these dues are paid within 60 days thereafter the election shall become void. An extract of the By-Laws relating to dues shall accompany the notice of election.

SEC. 5. Resignations from membership must be presented in writing to the Secretary on or before the close of the fiscal year and shall be acceptable provided the dues are paid for that year.

ARTICLE II.

OFFICERS.

SECTION 1. The officers shall be the President, two Vice-Presidents, six Directors (one from each geographical district), the Secretary and the Treasurer, who, with the five latest living Past-Presidents, who continue to be members, shall constitute the Board of Direction.

SEC. 2. The Board of Direction shall, from time to time, divide the territory occupied by the membership into six geographical districts, to be designated by numbers.

SEC. 3. There shall be a Committee of five members on Nomination of Officers, elected by letter ballot of the members of the Institute, which is to be canvassed by the Board of Direction on or before September 1 of each year.

The Committee on Nomination of Officers shall select by letter ballot of its members, candidates for the various offices to become vacant at the next Annual Convention and report the result to the Board of Direction who shall transmit the same to the members of the Institute at least 60 days prior to the Annual Convention. Upon petition signed by at least ten members, additional nominations may be made within 20 days thereafter. The consent of all candidates must be obtained before nomination. The complete list of candidates thus nominated shall be submitted 30 days before the Annual Convention to the members of the Institute for letter ballot, to be canvassed at 12 o'clock noon on the second day of the Convention and the result shall be announced the next day at a business session.

SEC. 4. The terms of office of the President, Secretary and Treasurer shall be one year; of the Vice-Presidents and the Directors, two years. Provided, however, that at the first election after the adoption of this By-Law, a President, one Vice-President, three Directors and a Treasurer shall be elected to serve for one year only, and one Vice-President and three Directors for two years; provided, also, that after the first election a President, one Vice-President, three Directors and a Treasurer shall be elected annually.

The term of each officer shall begin at the close of the Annual Convention at which such officer is elected, and shall continue for the period above named or until a successor is duly elected.

A vacancy in the office of President shall be filled by the senior Vice-President. A vacancy in the office of Vice-President shall be filled by the senior Director.

Seniority between persons holding similar offices shall be determined by priority of election to the office, and when these dates are the same, by priority of admission to membership; and when the latter dates are identical, the selection shall be made by lot. In case of the disability or neglect in the performance of his duty, of any officer of this Institute, the Board of Direction shall have power to declare the office vacant. Vacancies in any office for the unexpired term shall be filled by the Board of Direction, except as provided above.

SEC. 5. The Board of Direction shall have general supervision of the affairs of the Institute and at the first meeting following its election, appoint a Secretary and from its own members a Finance Committee of three; it shall create such special committees as may be deemed desirable for the purpose of preparing recommended practice and standards concerning the proper use of cement for consideration by the Institute, and shall appoint a chairman for each committee. Four or more additional members on each special committee shall be appointed by the President, in consultation with the Chairman.

SEC. 6. It shall be the duty of the Finance Committee to prepare the annual budget and to pass on proposed expenditures before their submission to the Board of Direction. The accounts of the Secretary and Treasurer shall be audited annually.

SEC. 7. The Board of Direction shall appoint a Committee on Resolutions, to be announced by the President at the first regular session of the Annual Convention.

SEC. 8. There shall be an Executive Committee of the Board of Direction, consisting of the President, the Secretary, the Treasurer and two of its members, appointed by the Board of Direction.

SEC. 9. The Executive Committee shall manage the affairs of the Institute during the interim between the meetings of the Board of Direction.

SEC. 10. The President shall perform the usual duties of the office. He shall preside at the Annual Convention, at the

meetings of the Board of Direction and the Executive Committee, and shall be ex-officio member of all committees.

The Vice-Presidents in order of seniority shall discharge the duties of the President in his absence.

SEC. 11. The Secretary shall be the general business agent of the Institute, shall perform such duties and shall furnish such bond as may be determined by the Board of Direction.

SEC. 12. The Treasurer shall be the custodian of the funds of the Institute, shall disburse the same in the manner prescribed and shall furnish bond in such sum as the Board of Direction may determine.

SEC. 13. The Secretary shall receive such salary as may be fixed by the Board of Direction.

ARTICLE III.

MEETINGS.

SECTION 1. The Institute shall meet annually. The time and place shall be fixed by the Board of Direction and notice of this action shall be mailed to all members at least thirty days previous to the date of the Convention.

SEC. 2. The Board of Direction shall meet during the Convention at which it is elected, effect organization and transact such business as may be necessary.

SEC. 3. The Board of Direction shall meet at least twice each year. The time and place to be fixed by the Executive Committee.

SEC. 4. A majority of the members shall constitute a quorum for meetings of the Board of Direction and of the Executive Committee.

ARTICLE IV.

DUES.

SECTION 1. The fiscal year shall commence on the first of July and all dues shall be payable in advance.

SEC. 2. The annual dues of each member shall be five dollars ($5.00).

SEC. 3. Any person elected after six months of any fiscal year shall have expired, need pay only one-half of the amount

of dues for that fiscal year; but he shall not be entitled to a copy of the Proceedings of that year.

SEC. 4. A member whose dues remain unpaid for a period of three months shall forfeit the privilege of membership and shall be officially notified to this effect by the Secretary, and if these dues are not paid within thirty days thereafter his name shall be stricken from the list of members. Members may be reinstated upon the payment of all indebtedness against them upon the books of the Institute.

ARTICLE V.

RECOMMENDED PRACTICE AND SPECIFICATIONS.

SECTION 1. Proposed Recommended Practice and Specifications to be submitted to the Institute must be mailed to the members at least thirty days prior to the Annual Convention, and as there amended and approved, passed to letter ballot, which shall be canvassed within sixty days thereafter; such Recommended Practice and Specifications shall be considered adopted unless at least ten per cent of the total membership shall vote in the negative.

ARTICLE VI.

AMENDMENTS.

SECTION 1. Amendments to these By-Laws, signed by at least fifteen members, must be presented in writing to the Board of Direction ninety days before the Annual Convention and shall be printed in the notice of the Annual Convention. These amendments may be discussed and amended at the Annual Convention and passed to letter ballot by a two-thirds vote of those present. Two-thirds of the votes cast by letter ballot shall be necessary for their adoption.

SUBJECT INDEX.

Address.
Annual — by the President. The Use of Concrete in Hydraulic Works. Richard L. Humphrey, 33.

American Concrete Institute.
Officers, 5.
Technical Committees, 6.
Past Officers, 8.
Summary of the Proceedings of the Tenth Annual Convention, 9.
Annual Report of the Board of Direction, 22.
Abstract of Minutes of Meetings of the Board of Direction, 27.
Register of Attendance — Tenth Convention, 31.
Charter, 541.
Change in Title of Organization, 542.
By-Laws, 544.
List of Publications, 562.

Architectural Stone.
Recommended Practice for Concrete —, Building Block and Brick, 352.
Standard Building Regulations for the Use of Concrete —, Building Block and Brick, 362.

Board of Direction.
Annual Report of the —, 22.
Abstract of Minutes of Meetings of the —, 27.

Brick (see Architectural Stone).

Bridges (see Highway Bridges).

Building Block.
Recommended Practice for Concrete Architectural Stone, — and Brick, 352.
Report of the Committee on — and Cement Products. C. K. Arp, Chairman, 344.
Standard Building Regulations for the Use of Concrete Architectural Stone, — and Brick, 362.

Building Regulations.
Standard — for the Use of Concrete Architectural Stone, Building Block and Brick, 362.

Cement (see also Portland Cement).
Investigation of the Durability of — Drain Tile in Alkali Soils. R. J. Wig and G. M. Williams, 65.
Report of Committee on Building Blocks and — Products. C. K. Arp, Chairman, 344.

Committee.
Report of — on Building Blocks and Cement Products. C. K. Arp, Chairman, 344.
Report of — on Concrete Roads and Street Pavements. C. W. Boynton, Chairman, 167.
Report of — on Reinforced Concrete Highway Bridges and Culverts. Willis Whited, Chairman, 219.
Report of — on Specifications and Methods of Tests for Concrete Materials. Sanford E. Thompson, Chairman, 422.
Report of — on Treatment of Concrete Surfaces. Leonard C. Wason, Chairman, 313.

Concrete.
Combination of Reinforcement and Forms in — Construction. T. W. Murray, 228.
— Posts to Fill the Gap. A. M. Smith, 365.
Full Size Tests and Their Value in — Construction. Burtis S. Brown, 299.
Methods and Cost of — Road Construction in Milwaukee County. H. J. Kuelling, 141.
Modern — Work Without Forms. James E. Payne, 506.
Progress and Development of — Work on the Delaware, Lackawanna and Western Railroad. A. B. Cohen, 239.
Progress Report on Tests of — in Sea Water at the Navy Yard, Charlestown, Mass. Leonard C. Wason, 265.
Recommended Practice for — Architectural Stone, Building Block and Brick, 352.
Recommended Practice for — Fence Posts, 358.
Recommended Practice for Plain — Pipe and Drain Tile, 345.
Reinforced — Pavements and Roadways. B. S. Pease, 112.
Report of Committee on — Roads and Street Pavements. C. W. Boynton, Chairman, 167.
Report of Committee on Reinforced — Highway Bridges and Culverts. Willis Whited, Chairman, 219.
Report of Committee on Specifications and Methods of Tests for — Materials. Sanford E. Thompson, Chairman, 422.
Report of the Committee on Treatment of — Surfaces. Leonard C. Wason, Chairman, 313.
Results of Tests on Plain and Reinforced — Tile. George P. Dieckmann, 60.
Some Essential Requirements in — Pavements. R. C. Stubbs, 108.

Concrete (*Continued*)
Standard Building Regulations for the Use of – Architectural Stone, Building Block and Brick, 362.
Standard Specifications for One-Course — Highway, 168.
Standard Specifications for One-Course — Street Pavement, 178.
Standard Specifications for Two-Course — Street Pavement, 188.
Steel Forms for — Construction. C. D. McArthur, 278.
Test of a Flat Slab Reinforced — Floor at Shredded Wheat Factory, Niagara Falls, N. Y. W. A. Slater, 385.
The Artistic Treatment of — Structures. Oliver Randolph Parry, 339.
The Expansion and Contraction of — Roads. R. J. Wig and W. S. Gefvert, 155.
The Layout of — Products Plants. E. S. Hanson, 485.
The Use of — in Hydraulic Works. Richard L. Humphrey, 33.

Construction.
Combination of Reinforcement and Forms in Concrete —. T. W. Murray, 228.
Full Size Tests and Their Value in Concrete —. Burtis S. Brown, 299.
Methods and Cost of Concrete Road — in Milwaukee County. H. J. Kuelling, 141.
Steel Forms for Concrete —. C. D. McArthur, 278.

Contraction.
The Expansion and — of Concrete Roads. R. J. Wig and W. S. Gefvert, 155.

Contractor.
The Problems of the —. Leonard C. Wason, 369.

Convention.
Register of Attendance, Tenth —, 31.
Summary of the Proceedings of the Tenth Annual —, 9.

Corrosion.
Some Comparative — Tests of Plastered Metal Lath—A Progress Report. J. C. Pearson, 445.

Cost.
Methods and — of Concrete Road Construction in Milwaukee County. H. J. Kuelling, 141.

Culverts.
Report of the Committee on Reinforced Concrete Highway Bridges and —. Willis Whited, Chairman, 219.

Discussion.
— on Combination of Reinforcement and Forms in Concrete Construction, 233.
— on Concrete Posts to Fill the Gap, 513.
— on Data on Lime Putty and Cream of Lime, 536.
— on Full Size Tests and Their Value in Concrete Construction, 306.
— on Methods and Cost of Concrete Road Construction in Milwaukee County, 146.
— on Reinforced Concrete Pavements and Roadways, 119.
— on Report of Committee on Concrete Roads and Street Pavements, 199.
— on Report of Committee on Specifications and Methods of Tests for Concrete Materials, 525.
— on Report of Committee on Treatment of Concrete Surfaces, 330.
— on Results of Tests of Plain and Reinforced Concrete Tile, 136.
— on Some Comparative Corrosion Tests on Plastered Metal Lath, 533.
— on Some Essential Requirements in Concrete Pavements, 124.
— on Specifications for Drain Tile, 134.
— on Steel Forms for Concrete Construction, 293.
— on The Artistic Treatment of Concrete Surfaces, 342.
— on The Expansion and Contraction of Concrete Roads, 162.
— on The Layout of Concrete Products Plants, 538.
Topical — on the Manufacture of Cement Products, 126.

Drain Tile (see also Tile).
Investigation of the Durability of Cement — in Alkali Soils. R. J. Wig and G. M. Williams, 65.
Specifications for —. A. Marston, 54.
Recommended Practice for Plain Concrete Pipe and —, 345.

Expansion.
The — and Contraction of Concrete Roads. R. J. Wig and W. S. Gefvert, 155.

Fence Posts (see Posts).

Flat Slab (see Floor).

Floor.
Test of a Flat Slab Reinforced Concrete — at Shredded Wheat Factory, Niagara Falls, N. Y. W. A. Slater, 385.

Forms.
Combination of Reinforcement and — in Concrete Construction. T. W. Murray, 228.
Modern Concrete Work Without —. James E. Payne, 506.
Steel — for Concrete Construction. C. D. McArthur, 278.

Highway.
Standard Specifications for One Course Concrete —, 168.

Highway Bridges.
Report of the Committee on Reinforced Concrete — and Culverts. Willis Whited, Chairman, 219.

Hydraulic Works.
The Use of Concrete in —. Richard L. Humphrey, 33.

Lime.
Data on — Putty and Cream of —. Cloyd M. Chapman, 459.

Metal Lath.
Some Comparative Corrosion Tests of Plastered —A Progress Report. J. C. Pearson, 445.

Methods.
— and Cost of Concrete Road Construction in Milwaukee County. H. J. Kuelling, 141.
Report of the Committee on Specifications and — of Tests for Concrete Materials. Sanford E. Thompson, Chairman, 422.

Pavements.
Reinforced Concrete — and Roadways. B. S. Pease, 112.
Report of Committee on Concrete Roads and Street —. C. W. Boynton, Chairman, 167.
Some Essential Requirements in Concrete —. R. C. Stubbs, 108.
Standard Specifications for One-Course Concrete Street —, 178.
Standard Specifications for Two-Course Concrete Street —, 188.

Pipe.
Recommended Practice for Plain Concrete — and Drain Tile, 345.

Plants (see Products).

Portland Cement (see also Cement).
Proposed Standard Specifications for — Stucco on Wood Lath, 324.
Standard Specifications for — Stucco, 315.
The Properties of — Having a High Magnesia Content. P. H. Bates, 470.

Posts.
Concrete — to Fill the Gap. A. M. Smith, 365.
Recommended Practice for Concrete Fence —, 358.

Presidential Address (see Address).

Proceedings (see Convention).

Products.
Report of the Committee on Building Blocks and Cement —. C. K. Arp. Chairman, 344.
The Layout of Concrete — Plants. E. S. Hanson, 485.

Publications.
List of —, 562.

Recommended Practice.
— for Concrete Architectural Stone, Building Block and Brick, 352.
— for Concrete Fence Posts, 358.
— for Plain Concrete Pipe and Drain Tile, 345.

Reinforced Concrete (see also Concrete).
— Pavements and Roadways. B. S. Pease, 112.
Report of Committee on — Highway Bridges and Culverts. Willis Whited, Chairman, 219.
Test of a Flat Slab — Floor at Shredded Wheat Factory, Niagara Falls, N. Y. W. A. Slater, 385.
Results of Tests on Plain and — Tile. George P. Dieckmann, 60.

Reinforcement.
Combination of — and Forms in Concrete Construction. T. W. Murray, 228.

Report.
Progress — on Tests of Concrete in Sea Water at the Navy Yard, Charlestown, Mass. Leonard C. Wason, 265.
— on Committee on Building Blocks and Cement Products. C. K. Arp, Chairman, 344.
— of Committee on Concrete Roads and Street Pavements. C. W. Boynton, Chairman, 167.
— of Committee on Reinforced Concrete Highway Bridges and Culverts. Willis Whited, Chairman, 219.
— of Committee on Specifications and Methods of Tests for Concrete Materials. Sanford E. Thompson, Chairman, 422.
— of Committee on Treatment of Concrete Surfaces. Leonard C. Wason, Chairman, 313.

Roads.
Methods and Cost of Concrete — Construction in Milwaukee County. H. J. Kuelling, 141.
Report of the Committee on Concrete — and Street Pavements. C. W. Boynton, Chairman, 167.
The Expansion and Contraction of Concrete —. R. J. Wig and W. S. Gefvert, 155.

Roadways.
Reinforced Concrete Pavements and —. B. S. Pease, 112.

Sea Water (see Concrete).

Specifications.
Report of the Committee on — and Methods of Tests for Concrete Materials. Sanford E. Thompson, Chairman, 422.
— for Drain Tile. A. Marston, 54.

Standard Specifications.
Proposed — for Portland Cement Stucco on Wood Lath, 324.
— for One-Course Concrete Highway, 168.
— for One-Course Concrete Street Pavement, 178.
— for Portland Cement Stucco, 315.
— for Two-Course Concrete Street Pavement, 188.

Steel Forms (see Forms).

Street Pavements (see Pavements).

Stucco.
Proposed Standard Specifications for Portland Cement — on Wood Lath, 324.
Standard Specifications for Portland Cement —, 315.

Surfaces.
Report of Committee on Treatment of Concrete —. Leonard C. Wason, Chairman, 313..

Tests.
Full Size — and Their Value in Concrete Construction. Burtis S. Brown, 299.
Progress Report on — of Concrete in Sea Water at the Navy Yard, Charlestown, Mass. Leonard C. Wason, 265.
Report of the Committee on Specifications and Methods of — for Concrete Materials. Sanford E. Thompson, Chairman, 422.
Results of — on Plain and Reinforced Concrete Tile. George P. Dieckmann, 60.
Some Comparative Corrosion — of Plastered Metal Lath—A Progress Report. J. C. Pearson, 445.
— of a Flat Slab Reinforced Concrete Floor at Shredded Wheat Factory, Niagara Falls, N. Y. W. A. Slater, 385.

Tile (see also Drain Tile).
Results of Tests on Plain and Reinforced Concrete —. George P. Dieckmann, 60.

Treatment.
Report of Committee on — of Concrete Surfaces. Leonard C. Wason, Chairman, 313.
The Artistic — of Concrete Structures. Oliver Randolph Parry, 339.

Use (see Concrete).

AUTHOR INDEX.

Abrams, D. A.
Discussion, 525.

Anderson, W. P.
Discussion, 308, 309, 311.

Arp, C. K.
Report of Committee on Building Blocks and Cement Products, 344.
Discussion, 131, 520, 523, 524.

Atwood, P. H.
Discussion, 129, 130, 131, 136, 139, 140, 151, 516.

Auten, C. A.
Discussion, 233, 234, 235, 236.

Bartlett, Warren G.
Discussion, 534.

Bates, P. H.
The Properties of Portland Cement Having a High Magnesia Content, 470.
Discussion, 165, 525, 534, 536, 537.

Bennett, R. B.
Discussion, 516, 519, 523.

Berryman, J. J.
Discussion, 539.

Bingham, L. L.
Discussion, 138.

Blair, W. P.
Discussion, 134, 136, 137.

Boorman, T. H.
Discussion, 122.

Boyer, E. D.
Discussion, 205, 208, 234, 330, 331, 338.

Boynton, C. W.
Report of Committee on Concrete Roads and Street Pavements, 167.
Discussion, 122, 123, 148, 152, 200, 201, 204, 205, 206, 207, 208, 210, 211, 212, 213, 214, 215, 216, 217, 528, 530, 531.

Brett, Allen.
Discussion, 151, 533.

Brown, B. S.
Full Size Tests and Their Value in Concrete Construction, 299.
Discussion, 236, 306, 307, 308, 309, 310, 312.

Chamberlain, O. P.
Discussion, 201, 202, 203, 206.

Chapman, C. M.
Data on Lime Putty and Cream of Lime, 459.
Discussion, 235, 236, 332, 333, 334, 335, 336, 338, 529, 531, 533, 536, 537.

Chubb, J. H.
Discussion, 136.

Clark, P. H.
Discussion, 237.

Cline, A. E.
Discussion, 128, 129, 130, 133, 134, 135, 150, 538.

Cohen, A. B.
Progress and Development of Concrete Work on the Delaware, Lackawanna and Western Railroad, 239.

Collings, W. A.
Discussion, 308, 309.

Condron, T. L.
Discussion, 307.

Connelly, John A.
Discussion, 213.

Cushing, W. C.
Discussion, 513.

DeBerard, W. W.
Discussion, 123, 205.

Dieckmann, G. P.
Results of Tests on Plain and Reinforced Concrete Tile, 60.
Discussion, 136, 137, 138, 139.

Dougherty, G. H.
Discussion, 140, 519, 521, 522.

Doyle, H. S.
Discussion, 122, 217.

Ewing, Davis.
Discussion, 128.

Ferguson, L. R.
Discussion, 146.

Gefvert, W. S.
The Expansion and Contraction of Concrete Roads, 155.

Hanson, E. S.
The Layout of Concrete Products Plants, 485.
Discussion, 131, 538, 539.

Heller, C.
Discussion, 307.

Humphrey, Richard L.
The Use of Concrete in Hydraulic Works, 33.
Discussion, 126, 128, 130, 131, 132, 140, 150, 153, 162, 163, 165, 200, 201, 202, 204, 205, 209, 211, 215, 216, 217, 330, 331, 332, 335, 338, 517, 523, 524, 531, 540.

Kerr, H. D.
Discussion, 306.

Kinney, W. M.
Discussion, 122, 218, 331, 522, 530, 532, 538.

Kuelling, H. J.
Methods and Cost of Concrete Road Construction in Milwaukee County, 141.
Discussion, 146, 147, 148, 149, 150, 151, 152; 153, 199, 200, 206, 211, 214.

Larned, E. S.
Discussion, 148, 149, 151, 152, 153, 164, 199, 202, 204, 205, 207, 210, 213, 214, 215, 216.

Lazell, E. W.
Discussion, 330.

Marston, A.
Specifications for Drain Tile, 54.
Discussion, 134, 135, 138, 139.

McArthur, C. D.
Steel Forms for Concrete Construction, 278.

McMaster, H. B.
Discussion, 237, 533, 534, 535.

Mensch, L. J.
Discussion, 119, 120, 306, 309, 310.

Miner, J. L.
Discussion, 203, 204, 206.

Murray, T. W.
Combination of Reinforcement and Forms in Concrete Construction, 228.

Parry, O. R.
The Artistic Treatment of Concrete Structures, 339.
Discussion, 200, 201, 236, 237, 331, 332, 333, 334.

Payne, J. E.
Modern Concrete Work Without Forms, 506.

Pearson, J. C.
Some Comparative Corrosion Tests of Plastered Metal Lath—A Progress Report, 445.

Pease, B. S.
Reinforced Concrete Pavements and Roadways, 112.
Discussion, 119, 120, 121, 122, 208, 209.

Raymond, H. S.
Discussion, 134, 140, 539.

Richardson, A. E.
Discussion, 140, 539.

Seaton, R. A.
Discussion, 528.

Skinner, T. H.
Discussion, 147, 233, 234, 298, 335, 342, 526, 535.

Slater, W. A.
Test of a Flat Slab Reinforced Concrete Floor at Shredded Wheat Factory, Niagara Falls, N. Y., 385.

Smith, A. M.
Concrete Posts to Fill the Gap, 365.
Discussion, 516, 517, 520, 522, 524.

Smith, B. S.
Discussion, 146, 213.

Smith, W. W.
Discussion, 134.

Stubbs, R. C.
Some Essential Requirements in Concrete Pavements, 108.
Discussion, 124, 125, 149, 207, 331, 540.

Talbot, A. N.
Discussion, 525, 527, 528, 529, 530.

Thompson, S. E.
Report of Committee on Specifications and Methods of Tests for Concrete Materials, 422.

Tubesing, W. F.
Discussion, 237, 238, 518, 528, 530, 532.

Wason, L. C.
Progress Report on Tests of Concrete in Sea Water at the Navy Yard, Charlestown, Mass., 265.
Report of Committee on Treatment of Concrete Surfaces, 313.
The Problems of the Contractor, 369.
Discussion, 235, 293, 298, 331, 527.

Whited, Willis.
Report of Committee on Reinforced Concrete Highway Bridges and Culverts, 219.

Wig, R. J.
Investigation of the Durability of Cement Drain Tile in Alkali Soils, 65.
The Expansion and Contraction of Concrete Roads, 155.
Discussion, 120, 121, 122, 124, 125, 162, 163, 164, 204, 205, 207, 208, 211, 212, 213, 215, 216, 529, 532, 534, 536.

Williams, G. M.
Investigation of the Durability of Cement Drain Tile in Alkali Soils, 65.

Williamson, F. L.
Discussion, 130, 132.

Wilson, E. B.
Discussion, 530.

Wilson, P. H.
Discussion, 146, 149, 162, 199, 201, 203, 208, 210, 211, 212, 213, 331, 334, 537.

Wood, Frederick.
Discussion, 513.

Zeidler, J. L.
Discussion, 135, 137, 139, 140, 540.

LIST OF PUBLICATIONS.

A. PROCEEDINGS.

VOLUME I.

Coloring of Concrete—J. P. Sherer.
Testing of Cement Blocks—John R. Allen.
The Dry Mixture of Concrete—A. L. Goetzmann.
Practical Work of Constructing Sidewalks—A. T. Gridley.
The Waterproofing of Concrete Blocks—G. B. Kirwan.
Waterproofing Concrete—W. H. Finley.
Cement Posts—J. A. Mitchell.
Mortar Sand—J. C. Hain.
Proceedings of the First Convention.
Discussion:
Coloring of Concrete.
Testing of Cement Blocks.
The Dry Mixture of Concrete.
The Practical Work of Constructing Sidewalks.
Register of Members in Attendance—First Convention.
List of Exhibitors First Cement Show.

VOLUME II.

Annual Presidential Address—Richard L. Humphrey.
Concrete Aggregates—Sanford E. Thompson.
Discussion.
Cement and Building Construction—C. A. P. Turner.
Discussion.
Concrete Building Blocks—S. B. Newberry.
Discussion.
Some Notes on Reinforced Concrete—A. L. Johnson.
The Use of Cement and Concrete for Farm Purposes—S. M. Woodward.
What the Cement Users Owe to the Public—R. W. Lesley.
Cement Block Architecture—Louis H. Gibson.
Waterproofing—J. L. Mothershead, Jr.
The Causes of Failure in the Concrete Block Business—O. U. Miracle.
The Selection of Portland Cement to be Used in the Manufacture of Concrete Blocks—Richard K. Meade.
Discussion.
Legislation Concerning the Use of Cement in New York City—R. P. Miller.
Discussion.
Legislation on Concrete Building Blocks—Will J. Scoutt.

Hair Cracks, Crazing or Map Cracks on Concrete Surfaces—Albert Moyer.
Report of Committee on Fireproofing and Insurance—E. T. Cairns.
Discussion.
Report of Committee on Art and Architecture—Charles D. Watson.
Discussion.
Machinery for Cement Users—W. W. Benson.
Topical Discussion on Cement Products.
Observations on the Testing and Use of Portland and Natural Cements—E. S. Larned.
Manufactured Stone—J. C. McClenahan.
Discussion.
The Manufacture and Use of Concrete Piles—Henry Longcope.
The Use of Salt in Concrete Sidewalk Construction—George L. Stanley.
Discussion.
Topical Discussion on Sidewalk Laying.
General Discussion on Cement and Concrete.
Summary of Proceedings of the Second Convention.
Register of Members in Attendance—Second Convention.
List of Exhibitors Second Cement Show.
Minutes of the Meetings of the Executive Board.
List of Members.

VOLUME III.

Summary of Proceedings of the Third Convention.
Annual Address by the President—The Successes and Failures of Cement Construction—Richard L. Humphrey.
Report of Committee on Sidewalks, Streets and Floors—George L. Stanley, Chairman.
Discussion.
Cement Sidewalk Paving—Albert Moyer.
Discussion.
Reinforced Concrete—W. K. Hatt.
Discussion.
Forms for Concrete Construction—Sanford E. Thompson.
Discussion.
Topical Discussion on the Manufacture of Concrete Blocks.
Selecting the Proportions for Concrete—William B. Fuller.
Discussion.
Report of Committee on Testing of Cement and Cement Products—E. S. Larned, Chairman.
Discussion.
The Artistic Treatment of Concrete—A. O. Elzner.
Concrete Surfaces—H. H. Quimby.
Discussion.
Treatment of Concrete Surfaces—Linn White.
Discussion.

Report of Committee on Art and Architecture—Charles D. Watson, Chairman.
Discussion.
Discussion on Streets, Sidewalks and Floors.
Concrete Blocks—Harmon H. Rice.
Discussion.
Tests of Building Blocks—R. D. Kneale.
Report of Committee on Machinery for Cement Users—J. F. Angell, Chairman.
Topical Discussion on the Manufacture of Cement Blocks.
Joint Meeting Sections on Testing Cement and Cement Products and on Concrete Blocks and Cement Products.
Waterproofing Cement Mortars and Concretes—The Asphalt Mastic Method—H. Wiederhold.
Discussion.
Waterproofing Cement Mortars and Concretes—The Elastic *vs.* the Rigid Method—Edward W. DeKnight.
Discussion.
Waterproofing Cement Mortars and Concretes—The Dry Compound Method—R. R. Fish.
Discussion.
Waterproofing Cement Mortars and Concretes—The Liquid Method—G. G. Fry.
Waterproofing Cement Mortars and Concretes—The Hydrocarbon Paint Method—S. J. Binswanger.
Discussion.
Report of Committee on Fireproofing and Insurance—E. T. Cairns, Chairman.
Report of Committee on Laws and Ordinances—H. C. Henley, Chairman.
Notes on the Investigation of Cement Mortars and Concretes in the United States Geological Survey Laboratories, at St. Louis, Mo.—Richard L. Humphrey.
Register of Members in Attendance—Third Convention.
List of Exhibitors Third Cement Show.
Report of the Executive Board.
Minutes of the Meetings of the Executive Board.
List of Members.

VOLUME IV.

Summary of Proceedings of the Fourth Convention.
Annual Address by the President—The Year's Progress in the Cement Industry and the Work of the Association—Richard L. Humphrey.
Tests of Reinforced Concrete Hollow Tile Floor Spans—W. K. Hatt.
Discussion.
Methods and Costs of Reinforced Concrete Construction with Separately Molded Members—William H. Mason.
Discussion.

The Necessity of Continuity in the Steel Reinforcement of Concrete Structures—E. P. Goodrich.
Discussion.
The Unit *vs.* The Loose Bar System of Reinforced Concrete Construction—Emile G. Perrot.
Discussion.
Factory-Made Concrete—Charles D. Watson.
Co-operation—What it is and What it can Accomplish—Robert W. Lesley.
Proportioning and Mixing Cement Mortars and Concrete—Leonard C. Wason.
Discussion.
Specifications for Cement Sidewalks—C. W. Boynton.
Report of the Committee on Streets, Sidewalks and Floors—George. L. Stanley, Chairman.
Discussion.
Standard Specifications for Portland Cement Sidewalks.
Report of Committee on Testing Cement and Cement Products—E. S. Larned, Chairman.
Standard Specifications for Cement Hollow Building Blocks.
Progress in Manufacture and Use of Cement Building Blocks—J. W. Pierson.
Topical Discussion on the Manufacture of Hollow Cement Blocks.
The Value of Sand in Concrete Construction—E. S. Larned.
General Discussion on the Use of Cement.
Report of the Committee on Machinery for Cement Users—Mentor Wetzstein, Chairman.
Report of the Committee on Fireproofing and Insurance—William M. Bailey, Chairman.
Report of the Committee on Laws and Ordinances—H. C. Henley, Chairman.
Report of the Committee on Art and Architecture—Charles D. Watson, Chairman.
Concrete from the Architect's Point of View—E. B. Green.
Exposed Selected Aggregates in Monolithic Concrete Construction—Albert Moyer.
Reinforced Concrete from the Contractor's Point of View—H. H. Fox.
Discussion.
Metal Forms in Reinforced Concrete Construction—W. L. Caldwell.
Discussion.
Manipulation of Forms in Concrete Construction—J. F. Swinnerton.
Reclamation of Arid Land—E. T. Perkins.
Waterproofing Cement Structures—James L. Davis.
Progress in the Investigation of Cement Mortars and Concretes in the Structural Materials Testing Laboratories of the United States Geological Survey, St. Louis, Mo.—Richard L. Humphrey.
Register of Members in Attendance—Fourth Convention.
List of Exhibitors Fourth Cement Show.
Report of the Executive Board.
Minutes of Meetings of the Executive Board.
List of Members.

VOLUME V.

Summary of Proceedings of the Fifth Convention.

Annual Address by the President. The Progress of the Association and the Necessity for Fireproof Construction—Richard L. Humphrey.

Cost of Concrete Construction as Applied to Buildings—Leonard C. Wason. Discussion.

Comparative Cost of Reinforced Concrete Buildings—Emile G. Perrot.

Monolithic Concrete Wall Buildings—Methods, Construction and Cost—Robert Aiken.

Cold Storage Warehouses of Reinforced Concrete Construction—J. P. H. Perry. Discussion.

Evolution of Reinforcement for Concrete—Harry F. Porter.

Concrete Applied to Dwelling House Construction—Ross F. Tucker.

Waterproofing—Various Applications and Comparative Costs—T. Hugh Boorman.

Methods of Attaching Shafting and Machinery in Reinforced Concrete Buildings—William M. Bailey.

Report of Committee on Art and Architecture—Albert Moyer, Secretary.

Decorative Concrete Stone—Frederick A. Norris.

Unburnable Homes—Their Artistic and Architectural Possibilities—Benjamin A. Howes.

The Construction and Cost of Small Concrete Houses—C. R. Knapp.

The Importance and Cost of Cement Testing—W. Purves Taylor.

The Availability of Concrete for Bridges—Its Cost and Durability—H. H. Quimby.

Cost of Reinforced Concrete Bridges, Especially with Regard to Maintenance—E. P. Goodrich.

Reinforced Concrete Retaining Walls—A. E. Lindau. Discussion.

The Applicability and Comparative Cost of Concrete and Reinforced Concrete for Subway Construction—Charles M. Mills. Discussion.

The Advantages of Reinforced Concrete for Railway Construction—B. H. Davis.

Concrete Piles—Forms, Advantages and Cost as Compared with Wooden Piles—C. W. Gaylord.

Value and Cost of Steel Centers for the Construction of Culverts and Bridges—L. H. Scott.

The Present and Future of the Cement Block—Its Manufacture, Its Availability, Its Cost—J. Augustine Smith.

Value and Cost of Steam Curing of Cement Hollow Blocks—F. S. Phipps.

Progress in the Use of Metal Forms with Comparative Costs—W. L. Caldwell. Discussion.

Cost and Value of Concrete Pavements—J. H. Chubb.

Report of Committee on Streets, Sidewalks and Floors—W. W. Schouler, Chairman.

Standard Specifications for Portland Cement Sidewalks.

Proposed Specifications for Concrete Roads.
Discussion.
Report of Committee on Insurance, Laws and Ordinances—W. H. Ham, Chairman.
Part I, on Insurance.
Part II, on Building Regulations.
Proposed Standard Building Regulations for Reinforced Concrete.
Discussion.
Report of Committee on Reinforced Concrete—Sanford E. Thompson, Chairman.
Discussion.
Report of Committee on Testing Cement and Cement Products—E. S. Larned, Chairman.
Standard Specifications for Cement Hollow Building Blocks.
Discussion.
Topical Discussion on Reinforced Concrete.
Report of the Executive Board.
Minutes of Meetings of the Executive Board.
Register of Members in Attendance—Fifth Convention.
List of Exhibitors Fifth Cement Show.
List of Members.
Geographical Distribution of Members.

VOLUME VI.

Summary of Proceedings of the Sixth Convention.
Annual Address by the President. The Use of Concrete in Europe—Richard L. Humphrey.
Reinforced Concrete Columns—Peter Gillespie.
Discussion.
Proposed Methods for the Reinforcement of Concrete Compression Members—Robert A. Cummings.
Discussion.
Longitudinal Reinforcement in Concrete Columns—Sanford E. Thompson.
Concrete for Maritime Structures—Chandler Davis.
The Essential Qualities and the Application of Concrete to Timber Structures in Sea Water for the Purpose of Increasing their Permanency—Ralph Barker.
Discussion.
The Efficiency and Cost of Concrete for the Preservation of Piles Exposed to Sea Water—C. C. Horton.
Results of Experiments upon Effect of Sea Water on the Tensile Strength of Various Mixtures of Cement and Sand—Cloyd M. Chapman.
Discussion.
Laying Concrete under Water—Detroit River Tunnel—Olaf Hoff.
Discussion.
Application of Concrete in Barge Canal Work—R. S. Greenman.
Discussion.

The Concrete Groined Arch in Filter and Covered Reservoir Construction—T. H. Wiggin.
A Simple Method of Computing the Strength of Flat Reinforced Concrete Plates—Angus B. MacMillan.
Discussion.
A Method for Long Span, Light Floor, Reinforced Concrete Construction with Comparative Cost—Emile G. Perrot.
The Preparation of Concrete—From Selection of Materials to Final Deposition—Harry Franklin Porter.
Report of Committee on Concrete and Reinforced Concrete—Alfred E. Lindau, Chairman.
Discussion.
Topical Discussion on Concrete and Reinforced Concrete.
Report of Committee on Building Laws and Insurance—William H. Ham, Chairman.
Part I.—Building Laws.
Standard Building Regulations for the Use of Reinforced Concrete.
Part II.—Insurance.
Topical Discussion on Insurance.
Report of Committee on Specifications for Fireproofing—Rudolph P. Miller, Chairman.
Concrete Construction with Separately Molded Members and Costs—Charles D. Watson.
Discussion.
Report of Committee on Exterior Treatment of Concrete Surfaces—L. C. Wason, Chairman.
Topical Discussion on the Exterior Treatment of Concrete Surfaces.
Reinforced Concrete for the Small House—C. R. Knapp.
Inexpensive Homes of Reinforced Concrete—Milton D. Morrill.
Discussion.
The Use of Concrete in Farm Buildings from a Sanitary Point of View—S. Cunningham, Jr.
Development of Concrete Road Construction—Fred R. Charles.
Discussion.
Notes on the Use and Cost of Concrete Blocks in Roadway Construction—George C. Wright.
Report of Committee on Roadways, Sidewalks and Floors—C. W. Boynton, Chairman.
Standard Specifications for Portland Cement Sidewalks.
Standard Specifications for Concrete Road and Street Pavements.
Standard Specifications for Portland Cement Curb and Gutter.
Topical Discussion on Roadways, Sidewalks and Floors.
Report of Committee on Specifications for Cement Products—W. P. Anderson, Chairman.
Proposed Standard Specifications for Architectural Concrete Blocks.
Proposed Standard Specifications for Plain Concrete Drain Tile.
Topical Discussion on Cement Products.

Waterproofing Concrete Without Altering Its Appearance—Cloyd M. Chapman.
Discussion.
Cost and Advantages of Concrete Drain Tile—J. H. Libberton.
Discussion.
Essentials in Cement Hollow Block Construction—Ernest B. McCready.
Installation and Operation of a Steam Curing Plant—F. S. Phipps.
Discussion.
Report of the Executive Board.
Minutes of Meetings of the Executive Board.
Register of Members in Attendance—Sixth Convention.

VOLUME VII.

Summary of Proceedings of the Seventh Convention.
Official Delegates, Seventh Annual Convention.
Annual Address by the President. Some Fallacies in Methods of Fireproofing—Richard L. Humphrey.
The National Fire Protection Association and Its Work—W. H. Merrill.
Some Thermal Properties of Concrete—Charles L. Norton.
Discussion.
Report of the Committee on Fireproofing—Rudolph P. Miller, Chairman.
Report of the Committee on Insurance—William H. Ham, Chairman.
An Incident of the Value of Concrete in Reducing the Cost of Insurance—Emile G. Perrot.
Discussion.
The Henry Hudson Memorial Bridge—William H. Burr.
Concrete Filled Steel Arches—H. H. Quimby.
Construction Problems in Concrete Bridges—Walter M. Denman.
A Test of a Flat Slab Floor in a Reinforced Concrete Building—Arthur R. Lord.
A Discussion of the Basis of Design for Reinforced Concrete Floor Slabs—Arthur R. Lord.
Discussion.
The Calculation of Reinforced Concrete Flat Plates Supported by Four Columns—L. J. Mensch.
Analysis of Results of Load Tests on Panels of Reinforced Concrete Buildings—Emile G. Perrot.
The Web Reinforcement of Concrete Beams—John Stephen Sewell.
Discussion.
Notes on Web Reinforcement—Peter Gillespie.
Problems Encountered in the Construction of the Aziscohos Storage Dam—Seth A. Moulton.
Concrete Construction. Testimony of the Roman Forum and Some Modern Examples—Alfred Hopkins.
The Use of Reinforced Concrete for Hospitals and Similar Structures—R. A. McColloch.
Reinforced Concrete School Buildings—John T. Simpson.

Use of Reinforced Concrete in San Francisco and Vicinity—John B. Leonard.
The Taylor Concrete Coal Breaker—R. D. Richardson.
Moving Forms for Reinforced Concrete Storage Bins—James MacDonald.
The Use of Reinforced Concrete in Sea Water—Raymond Baffrey.
Discussion.
Some Special Uses of Concrete in Mining—George S. Rice.
Report of the Committee on Reinforced Concrete and Building Laws—Alfred E. Lindau, Chairman.
Topical Discussion on Concrete and Reinforced Concrete.
Comparative Cost and Maintenance of Various Types of Building Construction—J. P. H. Perry.
Discussion.
Regulation Relative to the Design and Construction in Reinforced Concrete. Hungarian Society of Engineers and Architects.
The Measurement of Concrete Construction—Robert A. Cummings.
The Use of Compressed Air in the Handling of Mortar and Concrete—G. L. Prentiss.
The Spouting of Concrete—Fred E. Engstrum.
The Preparation and Handling of Concrete—H. M. Cryder.
Report of the Committee on Treatment of Concrete Surfaces—L. C. Wason, Chairman.
Proposed Standard Specifications for Portland Cement Stucco.
Standard Specifications for Scrubbed Concrete Surface.
Discussion.
Topical Discussion on the Treatment of Concrete Surfaces.
Dustless Concrete Floors—L. C. Wason.
Discussion.
Tufa Concrete—Joseph B. Lippincott.
Discussion.
Regulations Governing the Uniform Transportation and Examination of Cements and Trass—Hungarian Society of Engineers and Architects.
The Relation of the Lime Content of Cement to the Durability of Concrete—Henry S. Spackman.
Discussion.
The Insulation of Concrete, Especially below Grade—Edward W. DeKnight.
The Effect of Electrolysis on Metal Imbedded in Concrete—Cloyd M. Chapman.
Discussion.
Waterproofing with Water—Cloyd M. Chapman.
Discussion.
The Waterproofing of Tunnels—A. H. Harrison.
Topical Discussion on Waterproofing of Sewers.
Report of the Committee on Roadways, Sidewalks and Floors—C. W. Boynton, Chairman.
Some New Methods in Sidewalk and Curb and Gutter Construction—Jerome B. Landfield.
Topical Discussion on Roadways, Sidewalks and Floors.

Report of the Committee on Building Blocks and Cement Products—P. S. Hudson, Chairman.
Proposed Standard Specifications for Concrete Drain Pipe and Tile.
Proposed Standard Specifications for Architectural Concrete Stone.
Cement Drain Tile Plant—Layout and Operation—C. M. Powell.
Discussion.
Additional Notes on Steam Curing Plants—F. S. Phipps.
General Discussion on Cement Products.
Report of the Executive Board.
Minutes of Meetings of the Executive Board.
Register of Members in Attendance—Seventh Convention.

VOLUME VIII.

Summary of Proceedings of the Eighth Annual Convention.
Annual Address by the President. European Practice in Concrete Construction—Richard L. Humphrey.
Report of the Committee on Reinforced Concrete and Building Laws—A. E. Lindau, Chairman.
Discussion.
The Testing of Reinforced Concrete Buildings Under Load—W. A. Slater.
The Design of Concrete Flat Slabs—F. J. Trelease.
Discussion.
The Practical Design of Reinforced Concrete Flat Slabs—Sanford E. Thompson.
Discussion.
The Design of Concrete Grain Elevators—E. Lee Heidenreich.
Discussion.
Report of the Committee on Measuring Concrete—Robert A. Cummings, Chairman.
Proposed Standard Methods for the Measurement of Concrete Work.
Concrete Retaining Walls—John M. Meade.
Discussion.
Reinforced Concrete Piles—Robert A. Cummings.
The Handling of Concrete in the Construction of the Panama Canal—S. B. Williamson.
Use of Concrete in the Fourth Avenue Subway, Brooklyn, N. Y.—Frederick C. Noble.
The Use of Reinforced Concrete in Hypochlorite Water Purification Works—Walter M. Cross.
Design and Construction of the Estacada Dam—H. V. Schreiber.
Unit Cost of Reinforced Concrete for Industrial Buildings—C. S. Allen.
Reinforced Concrete Convention Hall at Breslau, Germany—S. J. Trauer.
The Suitability of Concrete for Gas Holder Tanks—Herbert W. Alrich.
Protection of Steel in Catskill Aqueduct Pipe Siphons—Alfred D. Flinn.
A Fireproof School of Concrete—Theodore H. Skinner.

The Present Status of Unit Concrete Construction—James L. Darnell.
Discussion.
Report of Committee on Specifications and Methods of Tests for Concrete Materials—Sanford E. Thompson, Chairman.
Aggregates for Concrete—William M. Kinney.
Discussion.
Field Inspection and Testing of Concrete—G. H. Bayles.
Comparative Tests of the Strength of Concrete in the Laboratory and in the Field—Rudolph J. Wig.
Discussion.
The Necessity for Field Tests of Concrete—Fritz Von Emperger.
Discussion.
Report of the Committee on Treatment of Concrete Surfaces—L. C. Wason, Chairman.
Discussion.
Cement Coatings—F. J. Morse.
Discussion.
Review of the Present Status of Iron Portland Cement—P. H. Bates.
Marine or Iron Ore Cements—Herman E. Brown.
Iron Ore Cement—Arthur E. Williams.
Discussion on Iron Ore Cement.
Flat Slab Concrete Bridges—William H. Finley.
Concrete Highway Bridges—Walter Scott Gearhart.
Concrete Bridges—Daniel B. Luten.
Discussion.
Report of Committee on Roadways, Sidewalks and Floors—C. W. Boynton, Chairman.
Standard Specifications for Portland Cement Sidewalks.
Standard Specifications for Concrete Roads and Street Pavements.
Standard Specifications for Concrete Curb and Concrete Curb and Gutter.
Standard Specifications for Plain Concrete Floors.
Standard Specifications for Reinforced Concrete Floors.
Discussion.
An Improved Concrete Pavement—E. W. Groves.
Cement Paving as Constructed at Mason City, Iowa—F. P. Wilson.
Discussion.
Report of the Committee on Building Blocks and Cement Products—P. S. Hudson, Chairman.
Recommended Practice for Plain Concrete Drain Tile.
Recommended Practice for Concrete Architectural Stone, Building Block and Brick.
Standard Specifications for Concrete Architectural Stone, Building Block and Brick.
Standard Building Regulations for the Use of Concrete Architectural Stone, Building Block and Brick.
Method of Testing Cement Pipe—Arthur N. Talbot and Duff A. Abrams.
Advantages and Durability of Cement Sewer Pipe—Gustave Kaufman.

The Manufacture and Use of Cement Drain Tile—Charles E. Sims.
Discussion.
Modern Methods of Manufacturing Concrete Products—Robert F. Havlik.
Notes on Reinforced Concrete Telegraph Poles—George Gibbs.
Concrete Fence Posts—W. J. Towne.
Concrete Fence Posts—L. J. Hotchkiss.
Discussion.
Report of the Executive Board.
Minutes of Meetings of the Executive Board.
Register of Members in Attendance—Eighth Convention.

VOLUME IX.

Summary of the Proceedings of the Ninth Annual Convention.
Annual Address by the President, The Use of Concrete in Mines—Richard L. Humphrey.
Effects of Electric Currents on Concrete—E. B. Rosa, Burton McCollum O. S. Peters.
Discussion.
Report of the Committee on Reinforced Concrete and Building Laws—Alfred E. Lindau, Chairman.
Principles of Design and Results of Tests on Girderless Floor Construction of Reinforced Concrete—T. L. Condron.
Measurement of Actual Stresses in a Cantilever Flat Slab Reinforced Concrete Floor having Rectangular Panels—Arthur R. Lord.
Discussion.
Design of Rigid Frames in Steel and Reinforced Concrete—Sanford E. Thompson and Edward Smulski.
Tests to Determine Lateral Distribution of Stresses in Wide Reinforced Concrete Beams—W. A. Slater.
Discussion.
The Present Status of Unit Methods of Reinforced Concrete Construction—John E. Conzelman.
Report of the Committee on Concrete Surfaces, presenting Standard Specifications for Portland Cement Stucco—L. C. Wason, Chairman.
Discussion.
Tests of Waterproofing for Concrete—Cloyd M. Chapman.
The Use of Cement on National Irrigation Works—Arthur P. Davis.
The Use of Concrete by the Bureau of Yards and Docks, U. S. Navy—H. R. Stanford.
Concrete in Railroad Work—M. A. Long.
Application of Concrete in the Abolishment of Grade Crossings in the City of Philadelphia—James W. Phillips.
Some Recent Applications of Concrete in Railroad Work—Frederick Auryansen.
Recent Applications of Concrete and Reinforced Concrete in the City of Pittsburgh—N. S. Sprague.
Discussion.

The Development of Concrete Grain Elevator Construction—R. P. Durham.
Concrete Elevators—Barney I. Weller.
Report of the Committee on Measuring Concrete, presenting Standard Methods for the Measurement of Concrete Work—Robert A. Cummings, Chairman.
Discussion.
Report of the Committee on Specifications and Methods of Tests for Concrete Materials—Sanford E. Thompson, Chairman.
Discussion.
The Constitution of Portland Cement. Some Results Obtained at the Experimental Cement Plant of the Bureau of Standards—P. H. Bates.
Discussion.
The Progress of the Work of the Bureau of Standards in Cement and Concrete—Rudolph J. Wig.
Sand and Gravel Washing Plants—Raymond W. Dull.
Topical Discussion on Concrete Floors, Sidewalks, Roads, Highway Bridges and Culverts.
Report of the Committee on Reinforced Concrete Highway Bridges and Culverts—Willis Whited, Chairman.
Discussion.
Report of the Committee on Roadways, Sidewalks and Floors—C. W. Boynton, Chairman.
Standard Specifications for Plain Concrete Floors.
Standard Specifications for Reinforced Concrete Floors.
Standard Specifications for Concrete Curb and Concrete Curb and Gutter.
Standard Specifications for Portland Cement Sidewalks.
Standard Specifications for Concrete Roads and Street Pavements.
The Concrete Roads of Wayne County, Michigan—Edward N. Hines.
Discussion.
Vibrolithic Concrete Pavements—R. C. Stubbs.
The Manufacture of Concrete Products in Germany—Julius Carstanjen, Jr.
Discussion.
The Coloring and Texture of Concrete Products—Adolph Schilling.
Reinforced Concrete Silos and Small Grain Bins—E. S. Fowler.
Annual Report of the Executive Board.
Minutes of Meetings of the Executive Board.
Register of Members in Attendance—Ninth Convention.

B. STANDARDS.

1. Standard Specifications for Cement. With Appendix on Standard Methods of Testing and Chemical Analysis.
2. Standard Specifications for Portland Cement Sidewalks.
3. Standard Specifications for Cement Hollow Building Blocks.
4. Standard Building Regulations for the Use of Reinforced Concrete.

5. Standard Specifications for One Course Concrete Highway.
6. Standard Specifications for Concrete Curb and Concrete Curb and Gutter.
7. Standard Recommended Practice. Report of Committee on Reinforced Concrete.
8. Standard Specifications for Scrubbed Concrete Surface.
9. Standard Recommended Practice for Plain Concrete Pipe and Drain Tile.
10. Standard Recommended Practice for Concrete Architectural Stone, Building Block and Brick.
11. Standard Specifications for Concrete Architectural Stone, Building Block and Brick.
12. Standard Building Regulations for the Use of Concrete Architectural Stone, Building Block and Brick.
13. Standard Specifications for Plain Concrete Floors.
14. Standard Specifications for Reinforced Concrete Floors.
15. Standard Specifications for Portland Cement Stucco.
16. Standard Methods for the Measurement of Concrete Work.
17. Standard Specifications for One Course Concrete Street Pavement.
18. Standard Specifications for Two Course Concrete Street Pavement.

C. REPORTS.

1. On Insurance.
2. On Treatment of Concrete Surfaces.
3. On Tests of Reinforced Concrete Buildings.